APRIL 2001

Final Draft

Calleguas Creek Nutrient TMDLs

Prepared for:
Calleguas Creek Watershed Management Plan
Water Resources/Water Quality Subcommittee
under an EPA Section 205(j) Grant awarded by
the State Water Resources Control Board
Agreement No. 7-120-250-0

Calleguas Creek Nutrient TMDLs
Final Draft

This project has been funded wholly or in part by the USEPA Assistance Agreement. The contents of this document do not necessarily reflect the views and policies of the USEPA, the State, nor does mention of trade names or commercial products constituent endorsement or recommendation for use.

Prepared by:
Larry Walker Associates
100 E. Thousand Oaks Blvd., Suite 124
Thousand Oaks, CA 91360

Calleguas Creek Nutrient TMDLs

Table of Contents

List of Tables

List of Figures

Executive Summary

Introduction

In the Calleguas Creek Watershed, thirty separate pollutants have been listed on the Clean Water Act Section 303(d) list of impaired waters. For each of these pollutants, a Total Maximum Daily Load (TMDL) must be developed to result in compliance with water quality standards. This document presents the TMDLs that address five of the 303(d) listings: ammonia, nitrate-N+nitrite-N, nitrogen, algae, and low dissolved oxygen/organic enrichment. These listings have been addressed through the development of separate TMDLs for ammonia, oxidized nitrogen (nitrate-N + nitrite-N), and algae/dissolved oxygen. However, because of the interconnected relationship between these listings and TMDLs, the three TMDLs have been bound together into this overall Nutrient TMDLs document with one introduction and one implementation plan for all three TMDLs. This summary describes the approach to developing the TMDLs and the numeric targets, source identification, wasteload and load allocations, margin of safety estimates, seasonal variation analysis, and the implementation plan developed for the TMDLs. Figure ES-1 shows the locations of the 303(d) listings for these constituents in the Calleguas Creek watershed.

Approach

The TMDLs were developed based on the current EPA regulations for TMDLs which were adopted on July 11, 2000 (EPA, 2000a). These regulations define the eleven minimum elements of a TMDL to be:

1. Name and geographic location of the 303(d) listed waterbody
2. Identification of the listed pollutant and applicable water quality standards
3. Quantification of the maximum allowable pollutant loads
4. Determination of current pollutant loads
5. Source identification
6. Wasteload allocations for point sources
7. Load allocations for non-point sources
8. Margin of safety
9. Consideration of seasonal variations
10. Allowance for foreseeable pollutant load increases
11. Implementation plan

Insert Figure of listings

Figure ES-1. Calleguas Creek 303(d) Listed Reaches

The introductory section of this document addresses the first of the ten elements required under the new TMDL regulations. Each of the three TMDL sections includes elements 2 through 10. The implementation plan is included as a separate section that presents the approach and actions for implementing all three TMDLs.

Each TMDL summarizes the existing conditions in the watershed and the basis for the 303(d) listing. Additionally, the applicable Basin Plan water quality objectives for each constituent are identified. These identified water quality standards were used as the basis for developing the numeric targets to be achieved within the watershed. In cases where the Basin Plan contained no numeric standard (algae) or a standard known to be outdated (ammonia), appropriate numeric targets had to be developed.

Once the numeric targets had been established, maximum allowable pollutant concentrations for each reach in the Calleguas Creek system were identified and compared to current receiving water concentrations to determine reaches requiring pollutant reductions. Wasteload and load allocations at levels that would result in achievement of water quality standards within each reach were established for significant sources contributing to the exceedance of the maximum allowable pollutant concentrations.

The TMDLs are expressed in terms of concentrations rather than loads. This approach is appropriate for these TMDLs because the watershed is effluent dominated and the beneficial use impacts of nutrients are based on concentration rather than loading. Correspondingly, the waste load allocations for wastewater treatment facilities and load allocations for non-point sources are expressed in term of concentrations.

Included in the development of the TMDL were a margin of safety, consideration of seasonal variations in the watershed, and a discussion of future growth impacts and loadings.

Key Points from the TMDLs

NUMERIC TARGETS

The numeric targets for the oxidized nitrogen TMDL were set equal to the Basin Plan objectives. For ammonia, the Basin Plan objectives are based on EPA criteria that are outdated. Therefore, the values presented in the 1999 updated EPA criteria document for ammonia, adjusted to reflect site-specific conditions, were determined to be the appropriate targets to protect beneficial uses in the watershed. The appropriate numeric targets for algae/dissolved oxygen were determined to be a "nuisance" algae biomass target for rivers and streams selected from literature and the Basin Plan dissolved oxygen objective for protection of aquatic life. The best mechanism for attaining the dissolved oxygen target was determined to be reducing Total Kjeldahl Nitrogen (TKN), the sum of ammonia and organic nitrogen. The choice of this mechanism for implementing the algae/dissolved oxygen TMDL clearly demonstrates the links between these TMDLs and the need to consider each in the context of the others. A algal biomass target for nuisance algae conditions for rivers and streams was identified from a review of the literature, but has not been demonstrated to be exceeded in the watershed. Further studies and monitoring are recommended in the Implementation Plan to better define the algae situation in the watershed and what constitutes "nuisance" conditions.

The ammonia and oxidized nitrogen targets apply to all reaches of the watershed. The dissolved oxygen target applies only to the Conejo Creek system, which is the only reach listed on the 303(d) list for low dissolved oxygen. The algal biomass targets only apply to the Conejo Creek system, Revolon Slough, and Beardsley Channel, because these are the only reaches for which algae is listed on the 303(d) list. The following table summarizes the nutrient targets for the watershed.

Table ES- 1. Nutrient Targets for the Calleguas Creek Watershed

Reach	30-day Average Ammonia Target (mg/L)[1]	1 hour Maximum Ammonia Target (mg/L)[1]	Nitrate-N + Nitrite-N Target (mg/L)	Dissolved Oxygen Target (mg/L)	Algal Biomass Target (mg/m^2 chl-a) [2]
Arroyo Simi Upper	1.8 x WER	3.9 x WER	10		
Arroyo Simi/Las Posas	2.7 x WER	8.4 x WER	10		
Dry Calleguas	1.0 x WER	5.7 x WER	10		
Arroyo Conejo Upper	1.7 x WER	3.2 x WER	10	Minimum 5.0	150
Arroyo Conejo Lower	3.1 x WER	8.4 x WER	10	Minimum 5.0	150
Arroyo Santa Rosa	2.4 x WER	5.7 x WER	10		
Conejo Creek Upper	3.3 x WER	5.7 x WER	10	Minimum 5.0	150
Conejo Creek Lower	3.5 x WER	4.1x WER	10	Minimum 5.0	150
Calleguas Creek Upper	2.7 x WER	2.7x WER	10		
Calleguas Creek Lower	2.2 x WER	2.7 x WER	10		
Revolon Slough and Ag Drains	2.5 x WER	4.9 x WER	10		150
Mugu Lagoon	2.7 x WER	2.7x WER	10		

1 A Water Effects Ratio (WER) is a mechanism for adjusting national criteria to reflect site-specific conditions in the Calleguas Creek watershed based on monitoring conducted in the watershed. In the event a site specific WER is not developed for a given reach, the WER for that reach will be set equal to 1.0.
2 This algal biomass target has been selected from literature and is not based on local consensus as to what constitutes nuisance conditions. This target can be adjusted based on further studies and public input.

SOURCE IDENTIFICATION

POTWs were identified as the most significant source of ammonia and TKN in the watershed. Non-point sources, groundwater, and atmospheric deposition did not contribute significant loads of ammonia or TKN to the creek system. For oxidized nitrogen compounds (nitrate+nitrite), POTWs are only a significant source if they have implemented nitrification treatment processes without also denitrifying. Agriculture contributes significant oxidized nitrogen loadings to the watershed, especially in Revolon Slough. Other non-point sources, groundwater, and atmospheric deposition contribute significantly smaller loadings of oxidized nitrogen. The following table summarizes the average annual loadings in the watershed from each of the sources for ammonia, oxidized nitrogen, and total nitrogen.

Table ES- 2. Average Annual Nitrogen Loadings in the Calleguas Creek Watershed

Source	Average Annual Ammonia-N Load (lb/yr)	% of Total Load	Average Annual Oxidized Nitrogen Load (lb/yr)	% of Total Load	Average Annual Total Nitrogen Load (lb/yr) [1]	% of Total Load
POTWs	946,771	92%	481,568	23%	1,573,274	45%
Agriculture	27,191	3%	1,359,022	66%	1,551,683	45%
Urban Runoff	23,245	2%	107,278	5%	181,546	5%
Open Space	24,825	2%	53,313	3%	107,447	3%
Groundwater	1,763	0.17%	61,547	3%	66,149	2%
Atmospheric Deposition	140	0.01%	913	0.04%	1,067	0.03%
Total for Watershed	1,023,935	100%	2,063,641	100%	3,481,166	100%

1 Total nitrogen loads were calculated as the sum of ammonia-N, nitrate-N, nitrite-N, and organic nitrogen loads in the watershed.

WASTELOAD AND LOAD ALLOCATIONS

Wasteload allocations (WLAs) for oxidized nitrogen and ammonia were set for five of the six POTWs in the watershed. Wasteload allocations were not determined for the Olsen Road treatment plant because it is in the process of being shut down. WLAs for TKN were developed only for the two treatment plants that discharge to the Conejo Creek system, the Hill Canyon and Camarillo plants. The Camrosa plant is able to achieve all proposed nutrient WLAs with existing facilities and operations. Moorpark is currently constructing facilities that will allow compliance with the WLAs by September, 2001. The Camarillo plant is able to achieve the proposed ammonia WLA with existing facilities and operations but would have to reduce oxidized nitrogen levels by about 70% to achieve the proposed WLAs for these pollutants. The Hill Canyon plant is able to achieve the proposed oxidized nitrogen and ammonia WLAs with existing facilities and operations but would have to reduce TKN levels by about 60% to achieve the TKN WLA. The Simi Valley plant would have to reduce ammonia levels by between 70% and 90% (depending on the site-specific adjustment to the ammonia criteria) to achieve the ammonia WLA and would have to reduce nitrate levels by between 40% and 70% (depending on the degree of nitrification needed to achieve the ammonia WLA) to achieve the oxidized nitrogen WLA.

Load allocations were set only for agricultural discharges of oxidized nitrogen. In the Calleguas Creek watershed, agriculture is assigned a load allocation of 10 mg/L of nitrate-N + nitrite-N. All other non-point sources of nutrients were sufficiently below the numeric target and comprised such a small portion of the total pollutant loading that they were not considered to be significant loadings and, consequently, were not assigned load allocations. Load allocations were assigned to agriculture as a category, rather than to individual dischargers. Agricultural loadings of oxidized nitrogen would require an average reduction of about 70% to meet the assigned load allocations. The following table shows the WLAs for each of the POTWs in the watershed.

Table ES- 3. Nutrient Wasteload Allocations

POTW	Ammonia-N Daily Effluent Limit [1] (mg/L)	Ammonia-N Monthly Effluent Limit [2] (mg/L)	Nitrate-N+Nitrite-N Daily Effluent Limit (mg/L)	Estimated TKN Daily Effluent Limit (mg/L)
Hill Canyon WWTP	8.4 x WER	3.1 x WER	10	3.5
Simi Valley WQCP	8.4 x WER	2.7 x WER	10	
Moorpark WWTP	8.4 x WER	2.7 x WER	10	
Camarillo WRP	4.1 x WER	3.5 x WER	10	4.4
Camrosa WWTP	2.7 x WER	2.2 x WER	10	

1 Acute effluent limits calculated based on the 95th percentile pH and temperature for the reach.
2 Chronic effluent limits calculated based on average pH and temperature for the reach.

MARGIN OF SAFETY

The wasteload and load allocations were calculated based on the assumption that no dilution of the discharges was available. However, some dilution flow is available in the watershed from groundwater and urban runoff that contain insignificant concentrations of nutrients. For the ammonia and oxidized nitrogen TMDLs, the margin of safety (MOS) was calculated based on this dilution. A MOS calculated in this manner varies depending on the amount of flow and the concentrations in the flow upstream of the discharges. The MOS for these TMDLs will be near zero under extreme watershed conditions (very low flows and high upstream concentrations) but will be greater than 10% of the TMDL for at least 90% of the time for both of these TMDLs. For the algae and dissolved oxygen TMDL, the MOS was calculated using numerous conservative assumptions in the development of the TKN WLAs. Only the TKN limit for Camarillo assumed any dilution. This TKN limit was based on the minimum amount of dilution possible under the future Conejo Creek Diversion Project. The MOS for the algae and dissolved oxygen TMDL is estimated to be between 25% and 50% based on conservative assumptions.

SEASONAL VARIATIONS

Implementation actions that result in compliance with water quality objectives during dry weather are also expected to result in compliance during wet weather conditions. POTWs are the most significant source of ammonia and TKN concentrations, and their concentrations do not change significantly during storm events. Monitoring data in the watershed indicates that stormwater concentrations of nutrients from non-point sources are generally lower than dry weather concentrations and are consistently lower than the TMDL targets (except for agricultural concentrations of oxidized nitrogen). Additionally, because the TMDLs are based on concentrations, any increase in loadings associated with storm events is accompanied by a proportionally greater increase in flow and, if anything, a reduction in concentrations. Therefore, implementation actions designed to meet the targets during dry weather critical conditions should also meet the targets during wet weather.

Implementation Plan

Implementation of the TMDLs is phased to allow implementation of the ammonia TMDL first and the oxidized nitrogen and algae/dissolved oxygen TMDLs at a second, later date. This approach was chosen for the following reasons:

- The implementation actions for ammonia impact the oxidized nitrogen and TKN concentrations in the watershed and therefore the implementation actions needed for these constituents. Phasing implementation will allow the conditions in the watershed to stabilize after the implementation of the ammonia TMDL and the impacts of its implementation on the other TMDLs to be assessed.
- Significant data gaps and uncertainties exist regarding the algae/dissolved oxygen TMDL. Additional data gathering efforts are required to determine the most appropriate implementation actions for this TMDL. Additionally, there is a possibility that implementation of the ammonia TMDL (because ammonia is a component of TKN) will result in compliance with the Basin Plan water quality objectives applicable to algae and dissolved oxygen.
- The Calleguas Creek Watershed Management Plan, to be adopted in 2005, will propose a coordinated plan to address all water quality issues within the watershed, including nutrients and other 303(d) listed pollutants. As such, the plan will serve as the ultimate implementation plan for all 30 TMDLs. Phasing implementation of these early Nutrient TMDLs, so that initiation of most costly structural controls is deferred until after 2005, will avoid the use of public and private resources on projects that may later prove to be inconsistent with the watershed plan.

The implementation plan includes a schedule with the dates on which wasteload allocations are to be incorporated into NPDES permits and load allocations go into effect. The following tables summarize the wasteload and load allocation implementation schedule.

Table ES- 4. Permitting Schedule [1]

Permit Number	POTW	Date Current Permit Expires	Date Ammonia WLAs Placed in Permits	Date for Achievement of Ammonia WLAs	Date Oxidized Nitrogen and TKN WLAs Placed in Permits	Date for Achievement of Oxidized Nitrogen and TKN WLAs
CA0056294	Hill Canyon	2001	2002	2002	2005	2005-2012
CA0055221	Simi Valley WQCP	2001	2002	2002	2005	2005-2012
CA0053597	Camarillo	2001	2002	2002	2005	2005-2012
CA0063274	Moorpark	2003	2002	2002	2005	2005-2012
CA0059501	Camrosa	2004	2002	2002	2005	2005-2012

1. Assumes Regional Board will adopt Nutrient TMDLs in March of 2002, place ammonia WLAs in NPDES permits by June of 2002, in accordance with the compliance schedule allowed in the Basin Plan, that the oxidized nitrogen and TKN targets are verified and/or adjusted to reflect new scientific information derived from the special studies in March of 2005, and that the WLAs are incorporated into the permits in October of 2005.

Table ES- 5. Load Allocation Implementation Schedule

Implementation Action	Implementation Date
Development of Agricultural Pollution Prevention Plan as part of the Calleguas Creek Watershed Management Plan	2005
Begin implementation of BMPs or other mechanisms to address oxidized nitrogen compounds	2006
Effective date of oxidized nitrogen target for Revolon Slough	2012

The schedules presented in Table ES- 4 and Table ES- 5 will result in attainment of ammonia standards by 2002 and attainment of oxidized nitrogen and dissolved oxygen standards no later than 2012. This is consistent with new EPA TMDL regulations which require that standards be attained within ten years of TMDL adoption.

The implementation plan also outlines special studies that may be conducted during the implementation period to address the uncertainties in the TMDLs. The following are potential studies that could be conducted:

- Development of a water effects ratio (site-specific objective) for ammonia based on hardness and ionic concentrations in the Calleguas Creek watershed.
- Examining the contribution of surface water loads of nitrogen to groundwater and the impacts of these loads on the groundwater recharge beneficial use.
- Assessment of the municipal water supply beneficial use designation for the watershed and potential de-designation of this use.

- Evaluating oxidized nitrogen loadings from different agricultural activities and investigating additional oxidized nitrogen loadings to Revolon Slough.
- Evaluation of the effectiveness of agricultural Best Management Practices
- Monitoring and assessment of "nuisance" algae conditions.
- Special assessment and monitoring of the unique physical and biochemical dynamics of Mugu Lagoon.

Finally, the implementation plan describes the monitoring program that will be used to measure progress toward attaining water quality standards and sets forth the conditions that could necessitate modification of the TMDLs. Those conditions include: (1) insufficient progress has been made toward attaining water quality standards; (2) special studies indicate the selected targets are inappropriate (i.e., over or under protective); and/or (3) the Calleguas Creek Watershed Management Plan demonstrates that the allocations, implementation plans, and/or schedules are inappropriate for the watershed.

Section 1. Introduction

Introduction

In the Calleguas Creek Watershed, thirty separate pollutants have been listed on the Clean Water Act Section 303(d) list of impaired waters. For each of these pollutants, a Total Maximum Daily Load (TMDL) must be developed to result in compliance with water quality standards. This bound document presents the TMDLs that address the 303(d) listings for ammonia, nitrate-N + nitrite-N, nitrogen, algae, and low dissolved oxygen/organic enrichment. These listings have been addressed through the development of separate TMDLs for ammonia, oxidized nitrogen (nitrate-N + nitrite-N), and algae/dissolved oxygen. However, because of the interconnected relationship between these listings and TMDLs, the documents have been bound together into this overall nutrient document with one implementation plan for all three TMDLs. This section presents introductory and background information common to all three TMDLs and discusses the connections between the three TMDLs and the overall nitrogen picture in the watershed. Subsequent sections 2, 3, and 4 describe the ammonia TMDL, the oxidized nitrogen TMDL, and the algae/dissolved oxygen TMDL, respectively. The final section contains the implementation plan for the three nutrient TMDLs presented in this document. An electronic copy of the data and calculations included in this report is available upon request.

TMDL Description and Regulatory Context

DESCRIPTION OF TMDL PROCESS

Section 303(d) of the Clean Water Act (CWA) requires States to identify waters where the effluent limitations required under the National Pollutant Discharge Elimination System (NPDES) or any other enforceable limits have been implemented and adopted water quality standards are still not attained. Lists of prioritized impaired water bodies are known as the "303(d)" lists and must be submitted to the United States Environmental Protection Agency (EPA) every two years.

A TMDL represents the total loading rate of a pollutant that can be discharged to a waterbody and still have the waterbody meet the applicable water quality standards. The TMDL can be expressed as the total mass or quantity of a pollutant that can enter the waterbody within a unit of time. In most cases, the TMDL determines the allowable loading capacity for a constituent and divides it among the various contributors in the watershed as wasteload (for point source discharges) and load (for nonpoint sources) allocations. The TMDL also accounts for natural background sources, seasonal variations, future growth, and provides a margin of safety.

TMDLs must include specific information to be approved by the EPA (EPA, 2000a). This information can be summarized by the following elements:

- **Name and Geographic Location**: The name and location of the impaired waterbody for which the TMDL is being developed.
- **Pollutant Identification**: Identification of the pollutant and applicable water quality standard for which the TMDL is being developed.
- **Maximum Pollutant Load**: Description of the numeric target for the TMDL and the pollutant load that may be present in the waterbody and still ensure attainment of the water quality standard.
- **Current Pollutant Loads**: A quantification of the current loads in the waterbody and the amount by which these current loads exceed the maximum allowable pollutant load.
- **Source Identification**: Identification of point and non-point sources of the pollutant for which wasteload and load allocations are being developed.
- **Wasteload and Load Allocations**: Pollutant reduction targets for point and nonpoint sources of pollution. Load allocations and wasteload allocations indicate maximum allowable loads from identified sources. Percent reductions can also be provided, and allocations should be compared with current loads to show the levels of reduction needed. Supporting information must be provided to demonstrate that wasteload and load allocations will result in attainment of the water quality standards.
- **Margin of Safety**: Account for uncertainties in the determination of the TMDL. The margin of safety can be expressed as unallocated load or as conservative analytical assumptions used in developing the TMDL.
- **Seasonal Variations**: Consider seasonal variations, stream water flow levels, and other environmental factors that affect the relationship between pollutant loadings and water quality impacts.
- **Foreseeable Pollutant Load Increases**: Allow for any reasonably foreseeable increases in pollutant loads including future growth.
- **Implementation Plan**: A description of actions necessary to implement the TMDL.

REGULATORY CONTEXT

In the Calleguas Creek watershed, the CWA is administered by the California Regional Water Quality Control Board, Los Angeles Region (Regional Board). This Regional Board is one of nine other regional boards in California. The State Water

Resources Control Board (State Board) establishes statewide policies and serves as the review and appeal body for the decisions of the regional boards.

The California Water Quality Control Plan, Los Angeles Region (Basin Plan), designates beneficial uses for surface and ground water, sets numeric and narrative water quality objectives necessary to support these beneficial uses, and describes implementation programs to protect waters in the region. The Basin Plan is the implementation plan for the Porter-Cologne Water Quality Act (also known as the "California Water Code") and serves as the State Water Quality Control Plan applicable to Calleguas Creek, as required pursuant to the federal CWA.

The 303(d) list is based on a biennial assessment of the region's water resources. These water quality assessments are used to identify, list and prioritize impaired waters for the development and implementation of TMDLs to meet water quality standards. Water quality standards include designated beneficial uses and numeric and narrative water quality objectives as specified in the Basin Plan. The EPA has oversight authority for the 303(d) program and must approve or disapprove the State's 303(d) lists and each specific TMDL. EPA is ultimately responsible for issuing a TMDL, if the State fails to do so in a timely manner.

As part of California's 1996 and 1998 303(d) list submittals, the Regional Board identified various reaches of the Calleguas Creek watershed as impaired due to ammonia, nitrate-N + nitrite-N, nitrogen, algae, and organic enrichment/low dissolved oxygen. A consent decree between the EPA, the Santa Monica BayKeeper and Heal the Bay Inc., represented by the Natural Resources Defense Council (NRDC), was approved on March 22, 1999. This consent decree requires that all TMDLs for the Los Angeles Region be adopted by EPA within 13 years. The consent decree also prescribes schedules for certain TMDLs. According to this schedule, TMDLs for nutrients, including ammonia, algae, and low D.O./organic enrichment in the Calleguas Creek watershed are to be adopted by March, 2002.

Watershed Description

WATERBODY NAME AND LOCATION

Physical Description

The Calleguas Creek watershed is located in the southern half of Ventura County, California. The waterbody originates in the Santa Susana mountains to the north and Santa Monica mountains to the southeast and flows 36 miles to Mugu Lagoon. The major tributaries to Calleguas Creek are the Arroyo Simi, Arroyo Las Posas, Arroyo Conejo, and Conejo Creek. Revolon Slough, in the western part of the County, is also considered part of the watershed, though the slough drains directly to Mugu Lagoon and only mixes with Calleguas Creek at the estuary. The drainage area of the watershed is approximately 325 square miles and includes the cities of Simi Valley, Moorpark, Thousand Oaks, and Camarillo. Figure 1-1 shows the watershed and locations of the tributaries.

Tributaries

The Arroyo Simi/Arroyo Las Posas reaches of the creek system flow through the cities of Simi Valley and Moorpark in the northern part of the watershed and join with Calleguas Creek near Somis Road. Upstream of Simi Valley, the creek is unlined and passes through open space and recreational areas. Through the city, the creek flows through concrete lined or rip rapped channels. Between Simi Valley and Moorpark, a distance of approximately 7 miles, the creek is unlined and without rip rap. From the edge of Moorpark to Hitch Blvd., the creek is once again rip rapped on the sides with a soft bottom throughout most of the channel, but in some areas, such as under bridges, the bottom is covered with concrete and rip rap. Downstream of Hitch Blvd., the Arroyo Las Posas passes through agricultural fields and orchards in a primarily natural channel. During most of the year, at the point where the channel reaches Seminary Road, the surface water flow has been lost to groundwater percolation or evaporation. During and after significant rains, surface flows in the Arroyo Simi/Las Posas may connect with flows from the Calleguas and Conejo Creeks and flow to Mugu Lagoon.

The Arroyo Santa Rosa, Arroyo Conejo, and Conejo Creeks run parallel to the Arroyo Simi/Las Posas in the southern portion of the watershed. The Arroyo Santa Rosa drains primarily open, rural residential, and agricultural land on the northern edge of the City of Thousand Oaks. The Arroyo Santa Rosa channel is a natural channel for most of its length with portions of rip rap and concrete lining along the sides and bottom of the channel in the vicinity of homes (such as near Las Posas Road). The Arroyo Conejo runs through Thousand Oaks and has three branches, the main fork, the north fork, and the south fork. The main fork of the Arroyo Conejo runs underground for most of its length. The portions that are above ground are concrete lined until the creek enters Hill Canyon on the western side of the city and converges with the south fork. The south fork runs through the southern and western portions of Thousand Oaks. For most of its length, the south fork flows underground or through concrete lined channels. The north fork runs through Thousand Oaks upstream of the Hill Canyon treatment plant. The channel is concrete lined for the portion that runs through the city, but becomes unlined when it nears the treatment plant. The main fork and the north fork converge approximately 0.4 miles downstream of the Hill Canyon Water Reclamation Plant. The Arroyo Conejo then merges with the Arroyo Santa Rosa to form Conejo Creek. Conejo Creek flows downstream approximately 7.5 miles before its confluence with Calleguas Creek. For most of the length of the Conejo and Calleguas Creeks, the sides of the channel are rip rapped, but the bottom is unlined.

Insert Figure

Figure 1-1. Calleguas Creek Watershed

Revolon Slough drains the agricultural land in the western portion of the watershed. The slough does not pass through any urban areas, but does receive drainage from tributaries that drain urban areas. The tributary starts as Beardsley Wash in the hills north of Camarillo. The wash is a rip rapped channel for most of its length and combines with Revolon Slough at Central Ave. in Camarillo. The slough is concrete lined just upstream of Central Ave. and remains lined for approximately 4 miles to Wood Road. From there, the slough is soft-bottomed with rip rapped sides. The lower mile to mile and a half of the slough to above Las Posas Road appear to be tidally influenced by inflows from Mugu Lagoon.

In addition to Revolon Slough, a number of agricultural drains (Oxnard Drain, Mugu Drain, Duck Pond Drain) serve as conveyances for agricultural and industrial drainage water to the Calleguas Creek estuary and Mugu Lagoon.

Mugu Lagoon

Mugu Lagoon is a valuable resource in Ventura County. It is one of the last remaining relatively undisturbed salt marsh areas in Southern California along the Pacific Flyway, and is habitat for many marine fish, mammals, and several threatened and endangered species (USDA, 1995). Because the lagoon is located on a naval base, there is limited access to the lagoon, but its value as a natural resource has been recognized. As such, some specific issues related to the lagoon are discussed in this section to provide background for the TMDLs that follow.

The lagoon consists of approximately 287 acres of open water, 128 acres of tidal flats, 40 acres of tidal creeks, 944 acres of tidal marsh and 77 acres of salt pan (California Resources Agency, 1997). It is comprised of a central basin into which flows from Revolon Slough and Calleguas Creek enter and two arms (eastern and western) which receive some drainage from agricultural and industrial drains. The salinity in the lagoon is generally between 31 and 33 parts per thousand (ppt) (Granade, 2001). The central basin of the lagoon has a maximum tidal range of approximately -1.1 to 7 feet (as compared to mean sea level) with smaller ranges in the two arms. Given this large tidal range, the volume of the lagoon is effectively flushed approximately twice per day. The western arm of the lagoon receives less tidal volume because of a bridge culvert that restricts the flows in that area. However, this area still turns over at least twice per day (Granade, 2001). The velocity of water traveling through the mouth of the lagoon is approximately 5-6 knots, which is a high velocity for a lagoon (Grigorian, 2001). The mouth of the lagoon never closes, apparently as a result of a large canyon present at the mouth of Calleguas Creek. The canyon prevents ocean sand from building up to a high enough level to close the mouth and likely accounts for the high velocities in the lagoon (Grigorian, 2001).

Vegetation

Open space habitats within the watershed comprise about 50% of the total watershed area and include four major habitats: coastal scrub with inclusions of chaparral; annual grassland with inclusions of oak savanna; riparian with inclusions of freshwater marsh; and saltwater marsh. Southern oak woodlands, riverine, eucalyptus, estuarine, and lacustrine habitats are present but make up less than 0.5% of the habitat area in the watershed.

Over 90% of the vegetation in the non-urban/non-agricultural areas of the watershed is coastal scrub, which is typified by low to moderate-sized shrubs with shallow root systems. In the Calleguas watershed, the coastal scrub type is dominated by California sagebrush, black sage, purple sage, and buckwheat. Golden yarrow, chaparral yucca, lupines, and monkeyflower are also found. Prickly pear cactus is found along the coast. The coastal scrub habitat varies from maritime succulent scrub near Pt. Mugu to Venturan coastal sage scrub in the areas farther inland.

Oak savanna and oak woodland occur as a minor element within the more widespread coastal scrub vegetation. Annual grasses are the predominate understory vegetation; and elderberry, baccharis, California sagebrush, and black sage can be locally abundant. Valley oak and, to a lesser extent, coast live oak, are the overstory trees in this type. These habitats are normally limited to the north and east facing slopes or deeper soil types where moisture is more abundant. The oak woodlands and savannas are important habitats, as they add vertical structure and diversity to the surrounding habitat types.

Extensive historical grazing and range improvement practices have allowed introduced Mediterranean annual grasses to replace much of the southern coastal sage scrub. Annual grassland now occupies about two percent of the watershed, most of it in the Simi Valley area. Agriculture has replaced native grassland areas, except in the Point Mugu State Park where some native perennial bunch grasses have survived.

Only about 0.5 percent of the watershed is riparian habitat. This habitat includes the freshwater marsh along the edges of streams (characterized by sedges, tulles, and cattails). The banks of permanent streams are characterized by willow, Western sycamore, Fremont cottonwood, Valley oak, and Coast live oak. Most of the riparian habitat areas have been replaced with grouted rock, concrete lining, rock rip-rap, bare dirt banks, orchards or crops. Virtually all of the freshwater emergent wetland that once covered most of the Oxnard Plain has been put into agricultural production. The only remaining wetland sites are about 900 acres of freshwater marsh set aside as game preserves and small fragmented instream areas along the various reaches of Calleguas Creek.

Saltwater marsh or saline emergent consist of zones of plants in intertidal and upper marsh areas. The dominant salt marsh species is pickleweed. The upper marsh areas are a mixture of pickleweed, sea lavender, alkali heath, juamea, salt grass, and arrowgrass. Saltwater marsh habitats are highly productive areas that provide food, cover, and nesting areas for a variety of species. The saltwater marsh habitat is primarily located in Mugu Lagoon and contains tidal marsh, tidal flats, and salt panne. (Vegetation section adapted from USDA, 1995)

Climate

The climate in the watershed is typical of the southern California coastal region. Summers are relatively warm and dry and winters are mild and wet. Eighty-five percent of the rainfall occurs between November and March with most of the precipitation occurring during just a few major storms. Annual rainfall in Ventura County averages 15 inches and varies from 13 inches on the Oxnard Plain to a maximum of 20 inches in the higher elevations (USDA, 1995).

Population/Human Alterations

Historically, the Oxnard Plain served as the flood plain for the creek. Starting in the 1850's, agriculture began to be practiced extensively in the watershed. By 1889, a straight channel from Highway 101 to the Conejo Creek confluence had been created for Calleguas Creek. In the 1920's, levees were built to channelize flow directly into Mugu Lagoon (USDA, 1995). Increased agricultural and urban land uses in the watershed resulted in continued channelization of the creek to the current channel system. The current land use in the watershed is approximately 26% agriculture, 24% urban, and 50% open space. Most of the agriculture is located in the middle and lower watershed with the major urban areas (Thousand Oaks and Simi Valley) located in the upper watershed.

Historically, Calleguas Creek was an ephemeral creek flowing only during the wet season. In the early 70's, State Water Project supplies began being delivered to the watershed. In 1957, the Camarillo Water Reclamation Plant came online, followed by the Hill Canyon Treatment Plant in Thousand Oaks in 1961. With the addition of State Water Project deliveries to the watershed and Publicly Owned Treatment Works (POTW) effluent, the Conejo/Calleguas system became a perennial stream by 1972 (SWRCB, 1997). When the Simi Valley Water Reclamation Plant began discharging in the early 1970's, the Arroyo Simi/Arroyo Las Posas became a perennial stream downstream of the plant to Seminary Road in Camarillo. However, surface flows from the Arroyo Simi/Arroyo Las Posas do not connect with surface flows from the Conejo Creek/Calleguas system during the majority of the year, except during high wet season flows.

The flow in Calleguas Creek and its tributaries is composed almost entirely of POTW effluent and urban and agricultural runoff. In the upper reaches of the watershed, groundwater seepage into the surface water provides some flow. As a whole, the waterbodies in this watershed can be classified as effluent-dependent waterbodies. As such, the development of TMDLs in this watershed is complicated by the fact that flow conditions in the watershed at the current moment are not necessarily indicative of what the flow conditions may be in the future. A good example of this is the Conejo Creek Diversion project.

The proposed Conejo Creek Diversion project in the Calleguas Creek watershed, when operational, will divert the majority of flow in Conejo Creek to agricultural uses in the Pleasant Valley area. The diversion project will be constructed approximately 7 miles downstream from the Hill Canyon WWTP. The water rights application allows the diversion of an amount equal to Hill Canyon's effluent minus 4 cfs for instream uses and channel losses. An additional amount of water equal to the flow contributed by use of imported water in the region (estimated at 4 cfs) may be diverted when at least 6 cfs of water will remain in the stream downstream of the diversion point (SWRCB, 1997). Natural flows due to precipitation will not be diverted. As a result of this project, flows in the lower reach of Conejo Creek could be less than half of the current flows in the creek.

Projects similar to the Conejo Creek Diversion project may be developed as part of the overall Watershed Management Plan for Calleguas Creek to address water resource, water quality, or flooding/erosion concerns. As such, TMDLs must be developed in a manner that considers the impacts of changing flows in the watershed and does not result in restrictions on the necessary use of the water for other purposes.

Beneficial Uses

The Calleguas watershed is listed as having several existing and potential beneficial uses in the 1994 Los Angeles Region Water Quality Control Plan (Basin Plan). These beneficial uses include:

- Municipal supply (potential)
- Warm water aquatic habitat (existing)
- Cold water aquatic habitat (existing and potential)
- Contact and non-contact recreation (existing and potential)

Table 1-1 lists the designated beneficial uses for Calleguas Creek and its tributaries.

Table 1-1. Beneficial Uses in the Calleguas Creek Watershed

Waterbody	Hydro Unit #	MUN	IND	PROC	AGR	GWR	FRSH	NAV	REC1	REC2	COMM	WARM	COLD	EST	MAR	WILD	BIOL	RARE	MIGR	SPWN	SHELL	WET
Mugu Lagoon	403.11							E	P	E	E			E	E	E	E	E	E	E	E	E
Calleguas Creek Estuary	403.11							P	P	E	E			E		E		E	E	E		E
Calleguas Creek	403.11	P*			E	E	E		E	E		E	E			E		E				E
Calleguas Creek	403.12	P*	E	E	E	E			E	E		E				E						
Revolon Slough	403.11	P*	P		E	E			E	E		E				E						E
Beardsley Wash	403.61	P*					E		E	E		E				E						
Conejo Creek	403.12	P*	E	E	E	E			E	E		E				E						
Conejo Creek	403.63	P*				I	I		I	I		I				E				E		
Arroyo Conejo	403.64	P*				I	I		I	I		I				E		E				
Arroyo Conejo	403.68	P*				I	I		I	I		I				E						
Arroyo Santa Rosa	403.63	P*				I	I		I	I		I				E						
Arroyo Santa Rosa	403.65	P*				I	I		I	I		I				E						
North Fork Arroyo Conejo	403.64	P*			E	E			E	E		E				E				E		
Arroyo Las Posas	403.12	P*	P	P	P	E			E	E		E	P			E						
Arroyo Las Posas	403.62	P*	P	P	P	E	E		E	E		E	P			E						
Arroyo Simi	403.62	P*	I			I	I		I	I		I				E		E				
Arroyo Simi	403.67	I*	I			I	I		I	I		I				E						
Tapo Canyon Creek	403.66	I*		P	P	I			I	I		I				E						
Tapo Canyon Creek	403.67	I*		P	P	I			I	I		I				E						
Gillibrand Canyon Creek	403.66	P*				I	I		I	I		I				E						
Gillibrand Canyon Creek	403.67	P*				I			I	I		I				E						
Lake Bard	403.67	E	E	E	E	P			P	E		E				E						

E - Existing Beneficial Use
P - Potential Beneficial Use
I - Intermittent Beneficial Use
* - Asterixed MUN designations are designated under State Board Regulation No. 88-63 and Regional Board Regulation No. 89-03. Some designations may be considered for exemptions at a later date.

DEFINITION OF REACHES

The Calleguas Creek watershed is defined as having between 2 and almost 20 reaches depending on the source of the information. The Basin Plan defines two reaches, above Portrero Road and below Portrero Rd., for the application of water quality standards, but lists beneficial uses for a much larger number (as shown in Table 1-1). The 303(d) list defines 14 reaches, but some of the reach locations are not clear or encompass reaches that are upstream and downstream of POTWs with different flow and water quality characteristics. For the purposes of determining TMDLs, reaches of the creek system were defined based on hydrology, monitoring stations and data, land use, and other applicable factors. The location of the reaches, lengths, major discharges to the reach and land uses are listed in Table 1-2. The reaches are shown in Figure 1-2.

Insert Figure

Figure 1-2. Calleguas Creek Nutrient TMDL Reaches

Table 1-2. Reach Descriptions [1]

					Land Use in Reach			
Reach No.	Reach	Description	Reach Drainage Area (sq. miles)	Length (miles)	Urban	Ag	Open	POTWs
1	Arroyo Simi Upper	Arroyo Simi upstream of Simi Valley WQCP	81.3	10.1	24%	0%	76%	None
2	Arroyo Simi/Las Posas	Arroyo Simi and Arroyo Las Posas downstream of SVWQCP to Seminary Rd.	84.5	13.8	11%	32%	57%	SVWQCP, Moorpark
3	Dry Calleguas	Calleguas Creek from Seminary Rd. to confluence with Conejo Creek	7.7	4.6	56%	33%	11%	None
4	Arroyo Conejo Upper	Arroyo Conejo upstream of Hill Canyon (North, South, and Main forks)	44.6	5.1, 5.7, 9.0 (North, South, Main forks)	52%	0%	48%	None
5	Arroyo Conejo Lower	Arroyo Conejo below Hill Canyon to confluence with Arroyo Santa Rosa	0.8	1.6	2%	0%	98%	Hill Canyon
6	Arroyo Santa Rosa	Arroyo Santa Rosa upstream of confluence with Arroyo Conejo	14.2	6.5	24%	22%	54%	Olsen Rd.
7	Conejo Creek Upper	Conejo from Arroyo Conejo and Arroyo Santa Rosa confluence to Camarillo WRP	15.7	6.2	25%	25%	50%	None
8	Conejo Creek Lower	Conejo Creek below Camarillo WRP to confluence with Calleguas Creek	2.0	1.3	3%	30%	67%	Camarillo WRP
9	Calleguas Creek Upper	Calleguas Creek downstream of confluence with Conejo Creek to Portrero Road	5.6	2.4	5%	25%	69%	Camrosa
10	Calleguas Creek Lower	Calleguas Creek downstream of Portrero Rd. to PCH	9.1	5.3	2%	59%	39%	None
11	Revolon Slough and Ag Drains	Revolon Slough, Beardsley Channel, Mugu Drain, Oxnard Drain, Duck Pond Drain, etc.	69.3	10.2, 6.6 (Revolon Slough, Mugu Drain)	18%	66%	16%	None (Nyeland Acres historically)
12	Mugu Lagoon	Mugu Lagoon from the Pacific Ocean to PCH.	7.9		19%	2%	79%	None

1. Information about these reaches was adapted from VCFCD, 1994b.

Water Quality Monitoring

Since 1952, various agencies have been conducting water quality monitoring in the Calleguas Creek watershed. Four major water quality monitoring efforts in the watershed have provided a significant amount of water quality information, including sample results for nitrogen compounds, pH, temperature and dissolved oxygen. These are useful for providing background information about the current and historical water quality in the watershed. This section summarizes the different monitoring programs that have collected data in the watershed.

The three major POTWs that regularly discharge to surface waters in the watershed (Simi Valley WQCP, Hill Canyon WWTP, and Camarillo WRP) collect samples from receiving water stations and their effluent on a monthly basis and run analyses for ammonia, nitrate, and nitrite. The Moorpark and Camrosa POTWs conduct more limited monitoring of their effluent and receiving water, because most of their effluent is reclaimed or used to recharge groundwater through percolation ponds. Since 1986, the City of Thousand Oaks has conducted quarterly sampling at ten stations along the Conejo and Calleguas Creeks. From 1991 to 1996, the Regional Board conducted watershed monitoring at 24 stations. Finally, in 1998 and 1999, an integrated watershed water quality monitoring program (Calleguas Creek Characterization Study) collected monthly samples at 12 receiving water and eight discharge locations in the watershed. An associated monitoring program was instituted under a 205(j) non-point source grant to attempt to quantify non-point source loads in the watershed. Table 1-3 summarizes the data collection efforts, the dates of sample collection, and number of stations.

Table 1-3. Summary of Water Quality Data in the Watershed

Data Source	Dates	Number of Discharge Stations[1]	Number of Receiving Water Stations
Calleguas Creek Characterization Study	7/98-6/99 (monthly)	8	12
205(j) Non-point sources Study (supplement to CCCS)	11/5/98, 5/5/99 dry, 2 wet 1/99	12	0
Ventura County Flood Control District (VCFCD) Stormwater data	1994-1999	8	2
POTW NPDES monitoring data	varies, 1991-present	5	9
Regional Board monitoring	1986-1995	4	20
Department of Water Resources	1952-1978	10	24
VCFCD and USGS dry weather monitoring	1975-1994	10	21
Thousand Oaks Characterization Study	1986-present	2	10
Arroyo Simi Characterization Study	1993-1994	1	7

1 Discharge includes tributaries to the main stems of the river for this analysis.

In each of the TMDL sections, data from these collection efforts are summarized or referenced, where relevant. Although data were available, no sample results collected prior to 1980 were used in the analysis, because the older data is no longer representative of current conditions.

Models

Conceptual models and a simple spreadsheet model were developed to help in the development of the TMDLs for nutrients. The conceptual models describe, in visual form, the watershed flow characteristics, inflows and outflows, and the nitrogen cycle within the creek system. For each reach of the creek system, areas of groundwater seepage and infiltration were identified and surrounding land use was used to estimate potential surface runoff into the system. Locations of POTW discharges were documented in the conceptual model. Separately, a conceptual model of the transformations and sources of nitrogen to an individual water parcel was created. These two conceptual models were used to develop a simple mass balance spreadsheet model of the watershed. The conceptual model for the watershed is separated into three segments (Simi, Conejo, and Revolon/Mugu) and shown in Figure 1-3 through Figure 1-5. The conceptual model for the nitrogen cycle is shown in Figure 1-6.

The Calleguas Creek system is a very complex, effluent-dominated waterbody. Modeling of the watershed is complicated by the fact that surface flows in the Arroyo Las Posas are not present during much of the year, agricultural inputs and extractions are numerous and difficult to quantify, and historical flow data is unavailable for several reaches. Because of these complexities, the adaptation of existing models, such as QUAL-2E, to the watershed is difficult. As a result, a simplified approach was used to assist in the understanding of the watershed processes. The spreadsheet model divides the creek system into several "compartments", each with a number of inputs and outputs. Steady state is assumed for each compartment, so that the flow and pollutant mass inputs to the compartment are assumed to equal the flow and mass outputs from the compartment. Within each compartment, nitrogen transformations between the different forms were modeled based on the size of the compartment and the travel time of the water through each compartment (residence time). All inputs and extractions were assumed to occur at the beginning of the compartment to simplify calculations of nitrogen transformations within the compartment. As a result, all inputs to the compartment were assumed to be converted over the entire length of the reach even though the actual inputs enter at various points along the reach.

Insert Figure

Figure 1-3. Conceptual Model of the Simi System

Insert Figure

Figure 1-4. Conceptual Model of the Conejo System

Insert Figure

Figure 1-5. Conceptual Model of the Revolon/Mugu System

Insert Figure

Figure 1-6. Conceptual Model of the Nitrogen Cycle

NITROGEN CYCLE REPRESENTATION

Within each compartment, a representation of the nitrogen cycle was created based on the concentrations of each nitrogen compound entering the compartment from the upstream station and all the inputs to the compartment. Instantaneous mixing was assumed within the compartment so the initial concentration of all the compounds was the sum of the inputs to the compartment.

The nitrogen cycle is represented by a series of complex differential equations. Because the change in the concentrations of each individual constituent is based on concentrations of other constituents that are themselves changing with time, there are no simple solutions to the equations. To simplify the nitrogen cycle description in the model, the concentrations of each constituent were assumed to be constant with time when they were the independent variable in the equation. For example, the nitrite concentration is dependent on the ammonia concentration in the waterbody. To calculate the change in nitrite concentrations, the ammonia concentration was held constant even though the ammonia concentration in the river would actually be changing with time as ammonia converts to nitrite.

Nitrification and denitrification rates were estimated during special study monitoring for the algae/dissolved oxygen TMDL (see description in Section 4). These rates were then compared to ranges presented in documentation for the QUAL-2E model (Brown, 1987). The QUAL-2E model was developed by the EPA to examine nutrient concentrations and loadings in surface waters. The nitrification rates estimated during the monitoring (3.5 to 5 per day) were higher than the values recommended in the QUAL-2E model (0.3-3 per day). These estimated values were entered into the model, and the ammonia, nitrite, and nitrate concentrations were compared to concentrations observed during the CCCS monitoring. The denitrification and nitrification rates were adjusted within the range of rates of the QUAL-2E model and the observed monitoring until the concentrations predicted by the model matched the observed concentrations as closely as possible.

FLOWS

Flow characterization of the watershed forms the basis of the spreadsheet model. A variety of flow measurements have been collected in the watershed, but only a few have been collected using reliable methods over a long enough period of time for analysis. The following table summarizes the sources of flow information, a description of their location, and the data available.

Table 1-4. Sources of Flow Information

Source of Flow Information	Location	Years of Record	Type of Measurement
Thousand Oaks Characterization Study	1 mile intervals on Conejo and Calleguas Creeks	Quarterly from 1986-present	Hand-held velocity meter
Arroyo Simi Characterization	4 stations on Arroyo Simi from Royal Rd. to Hitch Blvd.	Quarterly measurements 1993-1994.	Hand-held velocity meter
Calleguas Creek Characterization Study	15 stations throughout watershed	Monthly from 7/98-6/99	Estimates of width, depth, and velocity
VCFCD flow gauges			
803	Arroyo Simi at Madera Rd.	Daily from 1984-1999	Continuous monitoring permanent flow station
806	Calleguas Creek at Hwy 101	Daily from 1984-1999	Continuous monitoring permanent flow station
805	Conejo Creek at Santa Rosa Rd.	Daily from 1984-1999	Continuous monitoring permanent flow station
801	Calleguas Creek at Camarillo State Hospital	Daily from 1984-1999	Continuous monitoring permanent flow station
776	Revolon Slough at Laguna Rd.	Daily from 1984-1999	Continuous monitoring permanent flow station

Between the VCFCD flow gauges on Conejo Creek and lower Calleguas Creek and the Thousand Oaks Characterization Study measurements, flows on the Conejo Creek were considered to be accurately quantified. In addition, flow meters, rather than visual estimates, were used to determine flow during the CCCS by monitoring agencies on portions of the Conejo Creek. The available flow information on the Arroyo Simi/ Las Posas does not allow a similar flow characterization. There are two VCFCD gauges on this reach of the creek system, 803 and 806. Gauge 803 is located upstream of any POTW discharges in the watershed. Gauge 806 is located on Calleguas Creek in the portion of the system that is dry except for high, wet season flows. The Arroyo Simi Characterization and the CCCS represent one year of flow measurements on the system, and the CCCS results are estimates, not recorded flows. Therefore, the flow analysis developed for the Conejo/Calleguas system was used to address the areas of the Arroyo Simi where flow data were not available (i.e. downstream of the Simi Valley WQCP), as described below.

In developing these TMDLs, a flow regime for the Calleguas Creek watershed needed to be developed. Because the watershed is effluent-dependent and droughts do occur in the watershed, using a critical condition flow such as the 7Q10 or 1Q10 flow is not appropriate for this watershed. These flows would be close to zero in many of the Calleguas Creek reaches. For this reason, another, more appropriate flow regime had to be chosen. The critical condition for ammonia and algae/dissolved oxygen occurs during the summer months, therefore, only dry weather flows were considered in the analysis. For many objectives, including ammonia, there is a requirement that the objective not be exceeded more than once every three years (USEPA, 1999c). To match this requirement, the lowest monthly dry weather average with a return period of three years was used as the baseline flow. Table 1-5 lists the baseline flows, based on current POTW discharges, for each reach in the Calleguas Creek Watershed.

Table 1-5. Baseline Flows in the Calleguas Creek Watershed Reaches

Reach	Lowest 3-year Monthly Flow (cfs)
Arroyo Simi Upper	3.9
Arroyo Simi/Las Posas	18.0
Dry Calleguas	0
Arroyo Conejo Upper	4.0
Arroyo Conejo Lower	18.0
Arroyo Santa Rosa	1.0
Conejo Creek Upper	14.0
Conejo Creek Lower	12.0
Calleguas Creek Upper	11.0
Calleguas Creek Lower	12.0
Revolon Slough and Ag Drains	5.2
Mugu Lagoon	N/A

Once the base flow in the creek reach was established, the sources of the flow in the creek were estimated. POTW flows have been consistently recorded under NPDES permits and are well characterized. Median daily flows from each plant were calculated based on available NPDES data and the CCCS study data. Flow information for groundwater, open space, agricultural, and urban flow inputs were not readily available and so were estimated based on a number of assumptions discussed below.

Non-point sources of flow were estimated based on flow information from Revolon Slough, Arroyo Conejo upstream of Hill Canyon, and Arroyo Simi upstream of the SVWQCP. Because no POTWs currently discharge to any of these areas, it can be assumed that all the water comes from some combination of agricultural runoff, urban runoff, open space runoff, and groundwater seepage. In Revolon Slough, the channel is largely concrete-lined south of Highway 101 and is largely unlined north of Highway 101. All but the headwaters of Revolon Slough overlie the Oxnard Plain pressure basin, which is considered to have a clay cap separating shallow perched waters from the deeper fresh-water aquifers of the groundwater basin. In the area of the Oxnard Plain north of Highway 101, this clay cap is thinned, allowing surface waters to percolate into the fresh-water aquifers (US Geological Survey Regional Aquifer Study, in press). Based on this knowledge, it is assumed that water from Revolon Slough and its tributaries may percolate into the groundwater basin north of Highway 101. It is unlikely that groundwater seeps into the Slough in this area, because groundwater levels are well below the ground surface (United Water Conservation District, 2000). South of Highway 101, the clay cap prevents infiltration of significant amounts of surface water into the groundwater basin, and it is assumed that no water in Revolon Slough is from groundwater seepage.

The amount of water applied for irrigation varies by crop and by year. In wet years, less irrigation water is required and during dry years, more irrigation water is applied. According to estimates developed in 1999, during wet years 1.7 acre-ft/acre/yr were applied to crops and during a dry year 2.3 acre-ft/acre/yr were applied in the Calleguas Basin (Bachman, 2000). These numbers correlate well with the Agricultural Extension's estimate of an average application rate for irrigation water of 2 acre-ft/acre/yr. Of this average amount of water applied in the Calleguas Creek watershed, approximately 70% is lost to evapotranspiration, 12-24% remains in the soils or enters the groundwater, and 6-12% is discharged to the surface water (Kennedy Jenks, 1999). Assuming that only 6% of the applied water is discharged to surface water during the dry weather months, the amount of flow in Revolon Slough due to agriculture was estimated to be approximately 4.4 cfs. The estimates of agricultural runoff were developed for the watershed as a whole, and it is possible that the estimates may be low for Revolon Slough because of tile drains and potentially lower groundwater infiltration in the Oxnard Plain. Because all the flow in Revolon Slough is assumed to come from surface runoff of some kind and no significant flow is leaving the system, the flow in the system that was not attributed to agriculture based on the assumptions presented above was assumed to come from urban or open space runoff (approximately 0.8 cfs). The baseline flow not attributable to agriculture was multiplied by the urban and open space land use percentage in the watershed and an assumed runoff coefficient for the land use (0.58 for urban and 0.2 for open space) to estimate the proportion of flow in Revolon Slough from each of these land uses. This proportion was used to estimate a flow per unit area for each type of land use that could then be applied to the other areas of the watershed. The groundwater seepage for the Conejo Creek and Arroyo Simi were estimated based on the difference between the base flow in the upstream portion of each reach and the estimated runoff from the various land uses calculated from the Revolon Slough information. The following table summarizes the estimated flows from each land use by reach.

Table 1-6. Estimated Flows in Each Reach by Land Use

Reach	Estimated Agricultural Discharges (cfs)	Estimated Urban Discharges (cfs)	Estimated Open Space Discharges (cfs)
Arroyo Simi Upper	0.008	1.7	2.3
Arroyo Simi/Las Posas	2.8	1.3	2.5
Dry Calleguas	0	0	0
Arroyo Conejo Upper	0	1.8	0.84
Arroyo Conejo Lower	0.4	0.92	0.38
Arroyo Santa Rosa	0.3	0.31	0.31
Conejo Creek Upper	0.4	0.35	0.3
Conejo Creek Lower	0.14	0.077	0.16
Calleguas Creek Upper	0.15	0.01	0.17
Calleguas Creek Lower	0.47	0.025	0.19
Revolon Slough and Ag Drains	4.9	1.4	0.44
Mugu Lagoon	0.25	0.39	0.23

In developing estimated flows from the various discharges, the fact that runoff from different types of agriculture and different areas may vary was considered. For example, the tile drains in Revolon Slough may result in more runoff than in areas without tile drains. Additionally, row crops are likely to produce less runoff than orchards, and different soil types can have impacts on the amount of runoff (McIntyre, 2001). Finally, irrigation practices will have a significant impact on the amount of runoff from an agricultural field. However, estimates of the magnitude of the differences could not be quantified in the Calleguas Creek watershed. As a result, the estimates presented above do not account for these differences. For the purposes of estimating the magnitude of concentrations and loadings from agriculture, urban, and open space areas in the watershed, the analysis conducted above was considered to be sufficient based on the existing information available.

In addition to the sources of flow to the system, estimates of flow extractions from the system had to be determined. Work conducted in association with the Conejo Creek Diversion Project provided estimates of outflows from the Conejo/lower Calleguas Creek system (CH2M Hill, 1996; SWRCB, 1997), and the Arroyo Simi Characterization Study provided some information on the Arroyo Simi system. Estimates for evaporation, groundwater infiltration, and agricultural extractions were based on this work. Table 1-7 summarizes the information obtained from these reports.

Three different sources of information about agricultural extractions in the Conejo/Calleguas system were found. The information in the Water Rights Application and EIRs for the Conejo Creek Diversion Project both provide estimates of agricultural extractions for the reach above the diversion point and the reach below the diversion point. In the State Board decision, additional petitions for water rights for agriculture along the creek are included. The sum of these petitions is greater than the estimates provided in the application reports. In the 1996 Revised EIR for the diversion project, estimates of extractions per acre of agricultural land in the Conejo Creek area were estimated by Camrosa (CH2M Hill, 1996). When this estimate per acre is converted to acre-ft/yr, it is higher than the numbers presented in earlier EIRs but lower than the sum of the EIR estimates and the existing pumping capacity listed in the water rights decision from the State Board. As a result, agricultural extractions were assumed to equal this mid-range value of 2.75 AF/yr for the agricultural acreage along the creek.

No estimates are available about rates of surface water extraction for agriculture in the Arroyo Simi. Although there may be differences between the two regions, for the purposes of this analysis, the agricultural extraction rates in the Arroyo Simi/Las Posas were assumed to be similar to the extractions in the Conejo Basin.

For each extraction except evaporation, the load removed was based on the assumption of a well-mixed compartment. Evaporation was assumed to reduce pollutant flow only, and not the mass of pollutant in the waterbody.

Table 1-7. Flow Outputs in the Calleguas Creek Watershed

Location	Evaporation	Groundwater Infiltration	Agricultural/ Irrigation Extractions	Source of Information
Hill Canyon to Diversion Pt. (7 miles)	50 acre-ft/yr	1370 acre-ft/yr	1700 acre-ft/yr	Conejo Creek Diversion Project Mitigated Negative Declaration (Fugro, 1996)
Downstream Diversion Pt. to Mugu Lagoon			1955 acre-ft/yr	Conejo Creek Diversion Project Mitigated Negative Declaration (Fugro, 1996)
Above Highway 101			142 acre-ft/month (May-Nov.), 0 in Dec.-April-(994 acre-ft/yr total)	State Board Decision Appendix I (SWRCB, 1997)
Authorized Diversion Cal-Cel Marketing and Hiji Brothers			0.82 cfs (306 acre-ft/yr max)	State Board Decision (SWRCB, 1997)
Competing Water Rights Applications-existing uses Conejo Creek (application amount)			5.6cfs (3558acre-ft/yr max)	State Board Decision (SWRCB, 1997)
Competing Water Rights Applications-existing uses Calleguas Creek (application amount)			3.23 cfs (1751 acre-ft/yr max)	State Board Decision (SWRCB, 1997)
Competing Water Rights Applications-existing uses Conejo Creek (current pumping capacity)			7.9 cfs	State Board Decision (SWRCB, 1997)
Competing Water Rights Applications-existing uses Calleguas Creek (current pumping capacity)			11.18 cfs	State Board Decision (SWRCB, 1997)
Golf Course			2 cfs (660 acre-ft/yr max)	EIR (CH2M Hill, 1991)
Hill Canyon to Diversion Pt. (7 miles)		1370 acre-ft/yr	1720 acre-ft/yr for 6 extractions	EIR (CH2M Hill, 1991)
Downstream Diversion Pt. to Mugu Lagoon			1955 acre-ft/yr for 5 extractions	EIR (CH2M Hill, 1991)
Conejo Creek			2.75 AF/yr per acre or 4158 AF/yr	1996 EIR (CH2M Hill, 1996)
SVWQCP to Hitch Blvd.	0.2 cfs/mile	1.1 cfs/mile		Arroyo Simi Characterization (Montgomery Watson, 1995)

Based on this information, groundwater infiltration was assumed to equal 1.1 cfs/mile for the majority of the Arroyo Simi with adjustments in the lower portion of the system to ensure that the flow completely infiltrated by Seminary Rd. Groundwater infiltration in the Conejo system was assumed to equal 0.3 cfs/mile. Evaporation was assumed to equal 60 in/yr times the area of the waterbody in all reaches of the watershed.

USE OF THE MODELS

The assumptions and analyses used to develop the models form the basis of the information used to develop the three TMDLs in this document. The conceptual models were used to assess potential sources of nutrients to the watershed and identify processes that impact surface water concentrations of these constituents. The spreadsheet model was used to obtain a general idea of the impacts on surface water concentrations resulting from implementation of BMPs in the watershed.

Nitrogen Picture

As discussed in the introductory paragraph to this section, this document presents the TMDLs to address three different nitrogen compound listings and two listings (algae and dissolved oxygen/organic enrichment) that are potential effects of nitrogen compounds in the waterbody. As demonstrated in Figure 1-6, the various nitrogen compounds and effects are connected, and their impacts are closely related. For this reason, all of the TMDLs for these related compounds have been incorporated into this one document. The purpose of this section is to provide an overall picture of the total nitrogen levels in the watershed to lead into the discussion of the separate compounds. As there are no water quality objectives for total nitrogen, there are not TMDLs, load allocations, or wasteload allocations associated with total nitrogen. This section simply provides a discussion of the way in which nitrogen is transported through the system to provide a better understanding of the interactions between the various TMDLs presented in this document.

For the purposes of this report, total inorganic nitrogen and total nitrogen will both be discussed. Total inorganic nitrogen is the sum of ammonia-N, nitrite-N, and nitrate-N. Organic nitrogen is added to this to determine the total nitrogen values. Because ammonia is converted to nitrite and nitrate throughout the stream system, looking at total inorganic nitrogen gives a clearer picture of where the various compounds may be entering the system and where higher concentrations of nitrite and nitrate simply represent the oxidation of ammonia. Evaluating total nitrogen for the watershed provides an assessment of the magnitude of the sources of nitrogen to Calleguas Creek.

Total inorganic and total nitrogen concentrations and loads are presented in the following tables for each reach based on the flow information presented in Table 1-5. The percentage of the load to the watershed coming from urban runoff, agriculture, groundwater, atmospheric deposition, and open space is estimated and compared to the percentage of each land use in the reach. The load to Mugu Lagoon is presented as the estimated load to the lagoon from the creek system, not the amount that may actually be present in the lagoon. Because of the large fluctuations in the tidal prism and volume of the lagoon as compared to the amount of flow entering the lagoon from the watershed, it is difficult to provide an accurate estimate of the load of nitrogen in the lagoon itself.

Table 1-8. Dry Weather Total Inorganic and Total Nitrogen Loads in Each Reach

Reach	Average Total Inorganic Nitrogen Concentration (mg/L-N)	Dry Weather Total Inorganic Nitrogen Loading (lb/day)	Average Total Nitrogen Concentration (mg/L-N)	Dry Weather Total Nitrogen Loading (lb/day)
Arroyo Simi Upper	4.15	87	5.24	110
Arroyo Simi/Las Posas	16.1	1559	18.7	1815
Dry Calleguas	2.4	0	6.5	0
Arroyo Conejo Upper	2.31	50	3.31	72
Arroyo Conejo Lower	16.4	1593	19.0	1847
Arroyo Santa Rosa	2.20	12	2.71	15
Conejo Creek Upper	17.3	1303	20.0	1514
Conejo Creek Lower	14.2	920	17.0	1104
Calleguas Creek Upper	17.2	1018	19.8	1173
Calleguas Creek Lower	18.2	1178	22.7	1469
Revolon Slough and Ag Drains	51.6	1448	51.8	1453
Mugu Lagoon	21.4	9169	23.9	10571

Table 1-9. Average Annual Loads of Total Inorganic Nitrogen in the Calleguas Creek Watershed

Source	lb/yr (dry)	% of Total Dry Load	lb/yr (wet)	Total Annual Load	% of Total Load	% of Land Use
POTWs	1,361,248	67%	67,091	1,428,339	46%	N/A
Agriculture	610,081	30%	776,132	1,386,213	45%	26%
Urban Runoff	7,527	0.4%	122,996	130,523	4.2%	24%
Open Space	6,248	0.3%	71,890	78,138	2.5%	50%
Groundwater	60,336	2.9%	2,974	63,310	2.1%	N/A
Atmospheric Deposition	1,053	0.05%	(1)	1,053	0.03%	N/A
Total for Watershed	2,046,493	100%	1,038,109	3,087,576	100%	100%

1. Wet deposition assumed to be included in the wet weather runoff from the various land uses.

Table 1-10. Average Annual Loads of Total Nitrogen in the Calleguas Creek Watershed

Source	lb/yr (dry)	% of Total Dry Load	lb/yr (wet)	Total Annual Load	% of Total Load	% of Land Use
POTWs	1,499,376	67%	73,898	1,573,274	45%	N/A
Agriculture	624,146	28%	927,537	1,551,683	45%	26%
Urban Runoff	22,276	1.0%	159,270	181,546	5%	24%
Open Space	18,771	0.8%	88,676	107,447	3%	50%
Groundwater	63,042	2.8%	3,107	66,149	2%	N/A
Atmospheric Deposition	1,067	0.05%	(1)	1,067	0.03%	N/A
Total for Watershed	2,228,678	100%	1,249,381	3,481,166	100%	100%

1. Wet deposition assumed to be included in the wet weather runoff from the various land uses.

As shown in Table 1-9 and Table 1-10, POTWs and agriculture contribute almost equally to the total annual loads of nitrogen in the watershed. However, POTWs, because of the discharge of ammonia, contribute significantly more nitrogen to the watershed during dry weather than agriculture. The total nitrogen loads are comprised primarily of inorganic forms of nitrogen. These nitrogen forms are addressed in the ammonia and oxidized nitrogen TMDLs presented in sections 2 and 3 of this document. Section 4 addresses some of the potential impacts of nitrogen in the watershed from the perspective of the algae/dissolved oxygen. These nutrient TMDLs for the Calleguas Creek Watershed were developed based on the information presented in this introductory section. In the final section of this document, the implementation plan for all of the TMDLs is presented.

Section 2. Ammonia TMDL

Introduction

Nitrogen is present in several forms in aquatic environments. Cycling between the various inorganic and organic forms of nitrogen makes it difficult to address any of the forms separately from the others. In addition, nitrogen compounds can have impacts on algae and dissolved oxygen levels in the watershed. For this reason, the TMDLs for all nitrogen compounds in the watershed, specifically ammonia-N; nitrate-N, nitrite-N, and nitrate-N+nitrite-N (oxidized nitrogen compounds); and the associated algae/dissolved oxygen TMDL were developed at the same time. Introductory material describing the regulatory context of TMDLs, a description of the watershed, the total nitrogen budget for the watershed, and flow and modeling information common to all the nutrient TMDLs is presented in Section 1 of this nutrient TMDL document. This section presents the TMDL for ammonia-N, but is closely tied to - and must be considered in the context of - the other nutrient TMDLs.

Pollutant Identification and Applicable Standards

WATER QUALITY MONITORING AND 303(D) STATUS

Ammonia is included on the 1998 303(d) list as impairing various reaches of the Calleguas Creek watershed (SWRCB, 1999). Background information developed for the 1996 303(d) list indicates that ammonia is listed as impairing aquatic life beneficial uses in the Arroyo Simi, Arroyo Las Posas, Arroyo Conejo, Conejo Creek, and Calleguas Creek (RWQCB, 1996a).

The 303(d) listing for ammonia was based primarily on data collected by the POTWs under their NPDES permits, the Thousand Oaks Characterization Study, and Regional Board monitoring. Through these collection programs 322 samples were collected at 61 stations throughout the watershed. 303(d) listings were made on the basis of 14 reaches throughout the watershed. Monitoring stations within each of the reaches were used to determine whether or not the beneficial uses in the reach were impaired by ammonia. If more than 40% of the samples collected at the monitoring stations in the reach exceeded the ammonia objectives in the Basin Plan, the beneficial uses were considered to be impaired by ammonia (RWQCB, 1996a). The following table summarizes the water quality samples used as a basis for the 303(d) listings.

Table 2-1. Water Quality Results Used as Basis for 303(d) Listing for Ammonia [1]

Reach	Number of Stations	Number of Samples	Mean (mg/L-N)	Percent above Objective	Reach Listed? [2]
Calleguas Creek R1 (Estuary to Broome Ranch Rd.)	3	28	2.66	43%	Yes
Calleguas Creek R2 (Broome Ranch Rd. to Portrero Rd.)	2	25	3.54	52%	Yes
Calleguas Creek R3 (Portrero to Lewis/Somis Rd.)	6	59	4.64	69%	No
Conejo Creek R1 (Confluence Calleguas to Santa Rosa Rd.)	8	60	6.89	88%	Yes
Conejo Creek R2 (Santa Rosa Rd. to T.O. City Limit)	3	26	9.21	81%	Yes
Conejo Creek R3 (T.O. City Limit to Lynn Rd.)	5	58	6.49	57%	Yes
Conejo Creek R4 (Above Lynn Rd.)		No data			Yes
Arroyo Santa Rosa Tributary		No data			No listings
Arroyo Conejo North Fork	6	40	4.24	23%	Yes
Arroyo Las Posas R1 and R2 (Lewis-Somis Rd. to Moorpark Fwy)	5	4	3.95	100%	Yes
Arroyo Simi R1 (Moorpark Fwy to Brea Canyon)	9	7	6.24	57%	Yes
Arroyo Simi R2 (Above Brea Canyon)	3	2	0.09	0%	No
Beardsley Wash/Channel	3	1	0.6	0%	No
Revolon Slough	7	12	0.52	0%	No
Duck Pond Ag Drain	1	No data			No
Mugu Lagoon		No data			No

1. Data obtained from the 1996 Water Quality Assessment Data Summaries (RWQCB, 1996a).
2. Reaches listed as "No" were not listed on the 303(d) list for ammonia, but the reach is listed for other constituents. "No listings" indicates that there were no 303(d) listings at all for the reach.

The monitoring conducted by the POTWs during the CCCS and the Thousand Oaks Characterization Study subsequent to the 1996 and 1998 303(d) listing has confirmed the basis for most of these listings. The listing for Conejo Creek R4 (Above Lynn Rd.) (where no data were collected) resulted from all the reaches in the Conejo Creek system being combined into one listing in 1996 and then separated into different reaches in 1998. Monitoring data from the CCCS and Thousand Oaks Study indicate that ammonia objectives are not being exceeded upstream of the Hill Canyon WWTP. Samples collected under these programs exceeded ammonia objectives in reaches below POTWs. Upstream of the treatment plants and in Revolon Slough, where there are no POTW discharges, ammonia objectives are not exceeded.

WATER QUALITY OBJECTIVES

The un-ionized form of ammonia is an endogenously-produced toxicant that many fish species excrete through passive diffusion from their gills (EPA, 1999c). High concentrations of un-ionized ammonia in a waterbody reverse the diffusion gradients surrounding the gill and cause ammonia to build up in gill tissue and the blood causing toxicity to the organism. Ionized ammonia (ammonia ion) dissociates into un-ionized ammonia and hydrogen ion, with the degree of dissociation increasing with the pH and temperature of the water.

The Water Quality Control Plan for the Los Angeles Region (Basin Plan) lists objectives for ammonia nitrogen (ionized plus un-ionized ammonia) to protect cold and warm water aquatic life habitat, due to the toxicity of ammonia to fish. Both acute (1 hour) and chronic (4 day) toxicity values are presented for WARM and COLD waters. Tables are presented in the Basin Plan based on the following equations (EPA, 1985):

Acute 1-hour average concentration:

$$(\text{mg/L } NH_3) = \frac{0.52}{(FT*FPH*2)}$$

where:

$$FT = 10^{0.03(20-TCAP)} \quad ; \ TCAP \le T \le 30$$
$$\quad\;\; 10^{0.03(20-T)} \quad ; \ 0 \le T \le TCAP$$

$$FPH = 1 \quad ; \ 8 \le pH \le 9$$
$$\quad\;\; \frac{1 + 10^{7.4-pH}}{1.25} \quad ; \ 6.5 \le pH \le 8$$

TCAP = 20 ^{0}C; Waters designated as COLD
25 ^{0}C; Waters designated as WARM

T = Water temperature in ^{o}C

Chronic 4-day average concentration:

$$(\text{mg/L NH3}) = \frac{0.80}{(FT*FPH*RATIO)}$$

where FT and FPH are as above and:

$$RATIO = 16 \quad ; \ 7.7 \le pH \le 9$$
$$\quad\;\; 24 * \frac{(10^{7.7-pH})}{(1 + 10^{7.4-pH})} \quad ; \ 6.5 \le pH \le 7.7$$

TCAP = 15 ^{0}C; Waters designated as COLD
20 ^{0}C; Waters designated as WARM

The chronic objectives are lower than the acute objectives and represent the more stringent objectives to be met in the waterbody. Because this watershed is primarily designated as WARM with only a few reaches designated as COLD, the WARM chronic objectives from the Basin Plan are considered to be the appropriate objectives to use in the development of the TMDL. Table 2-2 summarizes the chronic ammonia objectives in the Basin Plan for WARM waters for the ranges of pH and temperature encountered.

Table 2-2. Four-day Average Objectives for Total Ammonia-N for WARM Designated Waters (Basin Plan)

pH	Temperature (°C)						
	0	5	10	15	20	25	30
6.50	2.5	2.3	2.2	2.1	2.1	1.4	1.0
6.75	2.5	2.3	2.2	2.1	2.1	1.4	1.0
7.00	2.5	2.3	2.2	2.1	2.1	1.4	1.0
7.25	2.5	2.3	2.2	2.1	2.1	1.4	1.0
7.50	2.5	2.3	2.2	2.1	2.1	1.4	1.0
7.75	2.3	2.1	2.1	2.0	1.9	1.4	0.97
8.00	1.5	1.4	1.3	1.3	1.3	0.90	0.65
8.25	0.85	0.80	0.76	0.74	0.74	0.53	0.39
8.50	0.48	0.45	0.44	0.44	0.44	0.32	0.24
8.75	0.28	0.26	0.25	0.25	0.26	0.20	0.16
9.00	0.16	0.16	0.16	0.16	0.17	0.13	0.11

The Regional Board, as a provision in the Basin Plan, requires that all permitted dischargers in the Los Angeles Region comply with the ammonia objectives or conduct studies leading to an approved site-specific objective for ammonia by 2002 (RWQCB, 1994).

In addition to the numeric objectives for ammonia listed in the Basin Plan, a narrative objective for biostimulatory substances is also included in the Basin Plan:

> "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."

Because ammonia is a bioavailable form of nitrogen that aquatic plants use in their growth, the narrative standard for biostimulatory substances is also applicable to ammonia.

Numeric Targets

DEFINITION OF TARGETS

The purpose of TMDLs is to protect beneficial uses. As such, the targets of the TMDL are the values that will result in protection of the beneficial uses. The targets may be the water quality objectives that have been set for the watershed. However, because in most cases water quality objectives were set at a national level and applied to a specific watershed, the objectives may not always be representative of the local conditions that affect the protection of beneficial uses. In the case of ammonia, some consideration of the applicability of the Basin Plan objectives as the TMDL target in this watershed is warranted.

The ammonia objectives in the Basin Plan are based on the 1985 ammonia criteria document produced by the EPA and updated in 1992. Since that time, the EPA has produced an updated ammonia criteria document (1999 Ammonia Criteria Update) which modifies the recommended criteria in the 1985 document. The primary changes in this criteria update are:

- Instead of basing the criteria on unionized ammonia concentrations, the criteria were modified to account for total ammonia toxicity and concentrations. One result of this change was that the acute criteria are no longer considered to be dependent on temperature.
- The 1985 document used an empirical relationship for pH and toxicity that was regressed from available data. The 1999 Ammonia Criteria Update uses a model to determine the pH relationship of the ammonia criteria.
- The chronic criteria were calculated using acute to chronic ratios in the 1985 criteria document. In the 1999 Ammonia Criteria Update, the chronic criteria were revised using values calculated from available chronic toxicity tests.
- The averaging period for the chronic criteria was revised to be 30 days instead of the 4-day averaging period presented in the Basin Plan. According to the 1999 Ammonia Criteria Update, the highest 4-day average concentration within the 30-day period should not exceed 2.5 times the 30-day average criteria.

The 1999 Ammonia Criteria Update sets the following equations as the new national criterion for ammonia in fresh water.

<u>Acute 1-hour average concentration in mg/L N (CMC)</u>:

For waters designated as COLD:

$$CMC = \frac{0.275}{1 + 10^{7.204-pH}} + \frac{39.0}{1 + 10^{pH-7.204}}$$

For waters designated as WARM:

$$CMC = \frac{0.411}{1 + 10^{7.204-pH}} + \frac{58.4}{1 + 10^{pH-7.204}}$$

Chronic 30-day average concentration in mg/L N (CCC):

When fish early life stages are present[1]:

$$CCC = \left(\frac{0.0577}{1 + 10^{7.688-pH}} + \frac{2.487}{1 + 10^{pH-7.688}}\right) * MIN(2.85, 1.45 * 10^{0.028 * (25-T)})$$

When fish early life stages are absent:

$$CCC = \left(\frac{0.0577}{1 + 10^{7.688-pH}} + \frac{2.487}{1 + 10^{pH-7.688}}\right) * 1.45 * 10^{0.028 * (25-MAX(T,7))}$$

In addition, the highest four-day average within the 30-day period should not exceed 2.5 times the CCC.

Overall, the changes in calculation methods between the 1985 and 1999 documents result in chronic objectives that are 1.6 to 3.4 times higher than the chronic objectives presented in the Basin Plan (See Table 2-2 and Table 2-3). Table 2-3 lists the 30-day chronic criteria for WARM designated waters with fish early life stages present and Table 2-4 lists the 1-hour acute criteria.

Table 2-3. Thirty-day Average Objectives for Total Ammonia-N for Waters Designated as WARM (1999 Update)

pH	Temperature (°C)						
	0	5	10	15	20	25	30
6.50	6.67	6.67	6.67	6.46	4.68	3.39	2.46
6.75	6.44	6.44	6.44	6.25	4.52	3.28	2.37
7.00	5.91	5.91	5.91	5.73	4.15	3.01	2.18
7.25	5.39	5.39	5.39	5.22	3.78	2.74	1.99
7.50	4.36	4.36	4.36	4.23	3.06	2.22	1.61
7.75	3.58	3.58	3.58	3.47	2.51	1.82	1.32
8.00	2.43	2.43	2.43	2.36	1.71	1.24	0.90
8.25	1.79	1.79	1.79	1.74	1.26	0.91	0.66
8.50	1.09	1.09	1.09	1.06	0.76	0.55	0.40
8.75	0.78	0.78	0.78	0.75	0.55	0.40	0.29
9.00	0.49	0.49	0.49	0.47	0.34	0.25	0.18

1 For temperatures of 15 °C and above, the chronic ammonia objective when fish early life stages are present is equal to the objective when fish early life stages are not present. The objective is designed to provide some relief in cold temperature situations in which biological nitrification processes may not be able to maintain sufficiently low ammonia concentrations, but, at the same time, sensitive fish life stages, on which the chronic objectives are based, are not present.

Table 2-4. One-Hour Average Objectives for Total Ammonia-N for WARM Designated Waters (1999 Update)

pH	Acute Objective (mg/L) [1]
6.50	48.83
6.75	43.32
7.00	36.09
7.25	27.87
7.50	19.89
7.75	13.25
8.00	8.41
8.25	5.20
8.50	3.20
8.75	2.01
9.00	1.32

1. The acute ammonia criteria in the 1999 update is not dependent on temperature

Additionally, a review of the literature associated with the development of the ammonia criteria (LWA, 1999) suggests that conditions in the Calleguas Creek watershed, such as hardness and ionic concentrations, could impact the toxicity of ammonia to species in the watershed. The target for the TMDL needs to consider these issues to ensure that beneficial uses are protected in the watershed based on the best available current science and information.

Studies used to determine the 1999 recommended criteria for ammonia indicate that increased hardness and concentrations of certain ions, such as potassium, may decrease the toxicity of ammonia to aquatic species (Ankley et al., 1995; Borgmann, 1994; Borgmann and Borgmann, 1997). Hardness and ionic concentrations in the Calleguas watershed are significantly higher than laboratory water used to determine the ammonia criteria. Hardness observed during the CCCS monitoring range from around 400 mg/L as $CaCO_3$ in Conejo Creek to over 600 mg/L as $CaCO_3$ in the Arroyo Simi. Hardness in Revolon Slough is even higher (1300 mg/L as $CaCO_3$ on average). Potassium concentrations in samples collected by a variety of agencies average over 30 mg/L throughout the watershed. Sodium concentrations average 115 mg/L in Conejo Creek, 130 mg/L in Arroyo Simi, 170 mg/L in the main branch of Calleguas Creek, and 710 mg/L in Revolon Slough. Studies conducted by Borgmann demonstrated that water with potassium concentrations of 8 mg/L produced LC50s for one species (*Hyalella Azteca*) that were 25 times higher than LC50s found in laboratory dilution water (Borgmann, 1997). The potassium concentrations in this watershed are significantly higher than 8 mg/L. Consequently, it is possible that ammonia toxicity may be reduced by the observed ionic concentrations in the watershed.

The studies described above indicate that a Water Effects Ratio (WER) for ammonia could be significant in this watershed. A WER is a ratio of the toxicity to organisms in sample water to laboratory dilution water that can be used to develop a site-specific objective for a constituent. Because toxicity tests comparing the toxic effects of ammonia on *Hyalella* in the Calleguas Creek watershed to laboratory dilution water have not been conducted, information presented in the Borgmann study was used to estimate the WER for the watershed. The Borgmann study developed an equation to estimate the LC50 for ammonia toxicity based on the sodium and potassium concentrations in the site water. Using the average potassium and sodium concentrations in the Calleguas Creek watershed, LC50 estimates were made at a pH of 8 and average temperature of 20 ^{o}C (both typically found in this watershed). The estimated LC50s were compared to the LC50 determined at this pH and temperature for tests in laboratory dilution water to estimate a WER.

Chronic toxicity tests on *Hyalella* were used in the development of the 1999 ammonia criteria update. *Hyalella* is the most sensitive species to chronic ammonia toxicity used in the development of the criteria. Because of this sensitivity and the studies that have been done on this species by Borgmann, the ratio of the LC50 estimates to the laboratory LC50 for *Hyalella* is considered to be an estimate of the magnitude of a WER that could be developed for this watershed. The following is the equation used to estimate the LC50 for the watershed and the resulting WER (using a sodium concentration of 125 mg/L and a potassium concentration of 30 mg/L).

$$LC50 = \frac{1}{(1-R_{U:T})/TU4 + R_{U:T}/TU3)}$$

where:

$TU3 = 0.161$

$$R_{U:T} = \frac{1}{(1 + 10^{pK-pH})}$$

$$TU4 = \frac{max * [Na]*[K]}{([Na] + HS_{Na})*([K] + HS_K)} + a * [Na]^n$$

$pK = 0.09018 + 2729.92/(273.2 + T)$
$n = 0.477$
$a = 0.441$
$max = 38.5$
$HS_{Na} = 1.53$
$HS_K = 0.291$

The estimated LC50 is 4.27 mg/L N and the laboratory LC50 is 1.45 mg/L N.

WER = 4.27/1.45 = 2.9

To obtain the site-specific objective (SSO) appropriate to the waterbody, the WER is multiplied by the existing criteria to obtain the SSO. In this case, the estimated SSO would be the existing criteria multiplied by a factor of 2.9 at a pH of 8 and temperature of 20°C. This estimate results from predictions from one species. In order to develop an SSO for ammonia, additional species, such as a sensitive fish species, will also need to be evaluated and possibly tested to determine the ultimate WER and SSO. Evaluating other sensitive test species in the WER study helps to account for different sensitivities among different taxonomic orders and ensure that the SSO is sufficiently protective for the waterbody.

The Basin Plan, 1999 updated criteria, and the SSOs based on the estimated WER give a range of ammonia targets, all of which are dependent on pH and some of which are dependent on temperature. The following table summarizes the pH and temperature ranges, means, and medians for the various waterbody reaches.

Table 2-5. Temperatures and pHs in the Calleguas Creek Watershed

	pH				Temperature °C			
Reach	**Min**	**Max**	**Mean**	**95th Percentile**	**Min**	**Max**	**Mean**	**95th Percentile**
Arroyo Simi Upper	6.50	8.90	8.06	8.40	7.2	30.0	16.9	23.3
Arroyo Simi/Las Posas	6.80	8.20	7.59	8.00	10.0	31.5	20.6	25.6
Dry Calleguas	6.60	8.20	7.39	8.11	12.8	30.0	18.6	28.0
Arroyo Conejo Upper	6.60	8.60	8.18	8.50	6.1	26.0	14.8	21.1
Arroyo Conejo Lower	6.60	8.20	7.46	8.00	11.7	26.1	20.2	24.4
Arroyo Santa Rosa	7.00	8.40	7.85	8.20	6.7	23.9	17.8	22.2
Conejo Creek Upper	6.80	8.20	7.51	8.00	11.7	29.0	18.4	25.0
Conejo Creek Lower	7.10	8.20	7.58	7.94	11.1	25.6	16.7	21.1
Calleguas Creek Upper	6.80	8.10	7.55	8.00	7.2	31.0	20.1	27.3
Calleguas Creek Lower	7.19	8.60	7.76	8.38	10.0	31.0	21.1	29.2
Revolon Slough and Ag Drains	5.20	8.30	7.68	8.20	10.0	23.9	18.0	23.6
Mugu Lagoon	7.10	8.30	7.60	8.02	10.0	29.0	19.5	29.0

Based on the numbers in Table 2-5, the ammonia objectives applicable to the waterbody reaches on average are summarized below for each of the different scenarios.

Table 2-6. Total Ammonia-N Target Ranges

	Basin Plan		1999 Update		WER	
Reach	Chronic [1]	Acute [2]	Chronic [1]	Acute [2]	Chronic [1]	Acute [2]
Arroyo Simi Upper	0.87	2.4	1.8	3.9	2.5-5.2	6.9-11.3
Arroyo Simi/Las Posas	2.7	5.6	2.7	8.4	7.8-7.8	16.3-24.4
Dry Calleguas	0.70	3.6	1.0	5.7	2.0-2.9	10.5-16.6
Arroyo Conejo Upper	0.68	1.9	1.7	3.2	2.0-5.1	5.6-9.3
Arroyo Conejo Lower	3.7	5.6	3.1	8.4	9.1-10.6	16.2-24.4
Arroyo Santa Rosa	1.5	3.6	2.4	5.7	4.3-7.0	10.5-16.6
Conejo Creek Upper	3.1	3.7	3.3	5.7	8.9-9.6	10.7-16.6
Conejo Creek Lower	2.7	2.5	3.5	4.1	7.9-10.2	7.3-11.9
Calleguas Creek Upper	2.7	1.7	2.7	2.7	7.9-7.9	5.0-7.7
Calleguas Creek Lower	1.9	1.7	2.2	2.7	5.4-6.4	5.0-7.7
Revolon Slough and Ag Drains	1.9	3.1	2.5	4.9	5.4-7.2	9.0-14.4
Mugu Lagoon	2.3	1.7	2.7	2.7	6.6-7.9	5.0-7.7

1. Chronic criteria calculated based on average pH and temperature for the reach.
2. Acute criteria calculated based on the 95th percentile pH and temperature for the reach.

The chronic criteria were calculated based on the average pH and temperature for the reaches using data for which both pH and temperature were available. A 95th percentile pH value was calculated from all of the pH data to determine the acute criteria.

The biostimulatory narrative standard is addressed under a separate TMDL for algae. The algae TMDL proposes Total Kjeldahl Nitrogen (TKN), defined as the sum of ammonia nitrogen and organic nitrogen, limits for the reaches of the watershed that are impaired due to low DO/organic enrichment potentially associated with algae concentrations. Because ammonia is a component of TKN, the algae TMDL does have some bearing on the targets developed for ammonia. However, the TKN target allows adjustments in loadings of ammonia and/or organic nitrogen. Regardless of the approach taken to meet the TKN targets, the ammonia concentrations will still have to meet the aquatic life targets discussed above. As a result, the aquatic life objectives are the targets used in the development of the TMDL for ammonia. An overall implementation plan for all the nutrient issues in the watershed will be developed to address the overlap between the ammonia and algae TMDLs.

Ammonia toxicity is a function of concentration, not load in the waterbody. Ammonia does not bioaccumulate in aquatic life. In the water, ammonia is gradually converted to other forms of nitrogen (nitrite and nitrate) or taken up by aquatic plants and other primary producers (algae, bacteria, fungi) to form organic nitrogen. Impairments of beneficial uses due to ammonia are based on its concentration in the water column. As a result of the impact, the TMDL will be based on a concentration target rather than a pollutant load. The wasteload allocations will be determined by multiplying the target concentrations by the flow and conversion factors (Q) from the discharger.

Although the Basin Plan ammonia objectives are the current objectives in effect in the watershed, the 1999 Ammonia Criteria Update, adjusted for site-specific conditions, represents the best available scientific information on the toxicity of ammonia to freshwater aquatic life. For this reason, the 1999 update criteria times a Water Effects Ratio (WER) will be used as the TMDL target for ammonia that can be present in each reach of Calleguas Creek. The 1999 ammonia criteria presented in Table 2-7 will vary with the temperature and pH of the waterbody. Provisions are included in the implementation plan for developing a WER (through EPA-approved procedures) for any reach of the waterbody. In the event that a site-specific WER is not developed for a given reach within the time frame specified in the implementation plan, the WER will be assumed to be 1.0, and the target will be the 1999 ammonia criteria. The following table summarizes the selected targets for the Calleguas Creek watershed.

Table 2-7. Total Ammonia-N Targets[1]

Reach	Chronic 30-day average target (mg/L-N)[2]	Acute 1-hour average target (mg/L-N)[3]
Arroyo Simi Upper	1.8 x WER	3.9 x WER
Arroyo Simi/Las Posas	2.7 x WER	8.4 x WER
Dry Calleguas	1.0 x WER	5.7 x WER
Arroyo Conejo Upper	1.7 x WER	3.2 x WER
Arroyo Conejo Lower	3.1 x WER	8.4 x WER
Arroyo Santa Rosa	2.4 x WER	5.7 x WER
Conejo Creek Upper	3.3 x WER	5.7 x WER
Conejo Creek Lower	3.5 x WER	4.1 x WER
Calleguas Creek Upper	2.7 x WER	2.7 x WER
Calleguas Creek Lower	2.2 x WER	2.7 x WER
Revolon Slough and Ag Drains	2.5 x WER	4.9 x WER
Mugu Lagoon	2.7 x WER	2.7 x WER

1 In the event a site specific WER has not been developed for a given reach, the WER for that reach will be set equal to 1.0.
2 Chronic criteria calculated based on average pH and temperature for the reach.
3 Acute criteria calculated based on the 95th percentile pH and temperature for the reach.

Source Identification

POTWS

A total of seven wastewater treatment plants have operated at some point in the watershed. Nyeland Acres was phased out of operation in December, 1998. Camrosa and Moorpark Water Reclamation Plants reclaim most of their effluent for use in agriculture or infiltrate their discharge in percolation ponds. Only during wet, winter months do either of the plants discharge any effluent to the receiving waters. Camarillo, Hill Canyon, Olsen Road and Simi Valley discharge year round to the Conejo, Arroyo Conejo, Arroyo Santa Rosa and Arroyo Simi, respectively. The following table summarizes the POTWs in the watershed, along with their design flows, receiving waters, and populations served.

Table 2-8. POTW Descriptions

POTW	Current Design Capacity (mgd)	Receiving water	Population Served [1]
Hill Canyon Wastewater Treatment Plant	10.8	North Fork Arroyo Conejo	100,000
City of Simi Valley Water Quality Control Facility	12.5	Arroyo Simi	101,830
Camarillo Sanitary District, Water Reclamation Plant	6.75	Conejo Creek	40,600
Moorpark Wastewater Treatment Plant	2	Arroyo Las Posas	26,932
Camrosa Wastewater Treatment Plant	1.5	Calleguas Creek during wet season	24,000[2]
Olsen Road Water Reclamation Plant	0.75	Arroyo Santa Rosa	7500

1 Estimated population served from Bookman Edmonston, 1997.
2 Information from Camrosa website (www.camrosa.com).

In May 1999, the City of Thousand Oaks began experimenting with nitrification and denitrification at the Hill Canyon WWTP. They are still working out the details of the processes, but still continuously nitrify and denitrify all of their effluent. Moorpark is currently expanding their plant to allow for more reclamation and percolation of the treated wastewater to avoid discharging to the Arroyo Las Posas. As part of this expansion, nitrification and denitrification facilities are being built that will provide treatment to any effluent discharged to the creek. Camarillo currently nitrifies, but does not denitrify its effluent. Simi Valley has no nitrification or denitrification facilities in place. Wastewater treated by Olsen Road will be transported to Hill Canyon by 2002, and the plant will be phased out of operation.

Concentrations of ammonia discharged from these treatment plants range from 0.6 to 32 mg/L-N based on data collected under the CCCS. The following table characterizes the ammonia discharges from each of these POTWs. The median concentrations were calculated from the CCCS data.

Table 2-9. Ammonia Concentrations and Loads from POTWs

POTW	Median Total Ammonia-N (mg/L)	Average Flow (cfs)	Average Load (lb/day)
Hill Canyon WWTP [1]	4.9	14	370
Simi Valley WQCP	24.7	14	1870
Camarillo WRP	2.2	3.2	34
Moorpark WWTP [2]	27.6	2	300
Olsen Rd. WRP	3.4	0.3	4.3

1. Hill Canyon concentration determined from the values reported in their 1999 annual report after nitrification was implemented.
2. Average flow for Moorpark when discharging to the Arroyo Las Posas.

OTHER SOURCES

Other sources of ammonia in the watershed appear to be much less significant than the POTW loadings. Concentrations of ammonia collected at stations upstream of Hill Canyon and Simi Valley WQCP and on Revolon Slough were less than 0.3 mg/L-N on average and often less than the detection limit of 0.2 mg/L-N. Additionally, 205(j) monitoring of nonpoint sources in the watershed reported concentrations near to or below the detection limit for agricultural, urban, and open space discharges. As a result, POTWs are considered to be the only significant source of ammonia in the watershed.

Although POTWs are the major source of ammonia in the watershed, the other sources in the watershed were characterized. Identification of these sources and quantification of the loads from these sources were estimated based on the assumptions used to develop a simple mass load spreadsheet model to characterize nitrogen compounds in the watershed. Concentrations in runoff from each source and estimated flows were used to approximate loads from the other known sources in the watershed (See description of model and assumptions in Section 1).

Urban and Agricultural Sources

Surface runoff loads were estimated based on three land use categories: urban, agriculture, and open space. For each land use category, median concentrations observed in dry weather runoff during the 205(j) monitoring were used as the basis for calculation of loads. Flow estimates were not consistently collected during the 205(j) monitoring, making it difficult to directly calculate non-point source loads based on these data alone. As a result, load estimates were made based on the flow estimations presented in the model. Table 2-10 summarizes the estimated concentrations, flows, and loads by land use for each reach.

Table 2-10. Ammonia-N Concentrations and Loads from Surface Runoff

Reach	Arroyo Simi Upper	Arroyo Simi/Las Posas	Dry Calleguas	Arroyo Conejo Upper	Arroyo Conejo Lower	Arroyo Santa Rosa	Conejo Creek Upper	Conejo Creek Lower	Calleguas Creek Upper	Calleguas Creek Lower	Revolon Slough	Mugu Lagoon	Watershed
Urban Dry Weather													
Median Total Ammonia-N Concentration (mg/L)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
Estimated Flow (cfs)	1.7	1.3	0	1.8	0.92	0.31	0.35	0.077	0.010	0.025	1.4	0.39	
Estimated Load (lb/day) [1]	0.90	0.68	0	0.97	0.49	0.16	0.19	0.042	0.0054	0.013	0.75	0.21	4.4
Agriculture Dry Weather													
Median Total Ammonia-N Concentration (mg/L)	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	
Estimated Flow (cfs)	0.0080	2.8	0	0	0.39	0.29	0.39	0.14	0.15	0.47	4.9	0.25	
Estimated Load (lb/day)	0.010	3.7	0	0	0.51	0.37	0.51	0.18	0.19	0.61	6.4	0.32	12.8
Open Space Dry Weather													
Median Total Ammonia-N Concentration (mg/L)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
Estimated Flow (cfs)	2.3	2.5	0	0.84	0.38	0.31	0.30	0.16	0.17	0.19	0.44	0.23	
Estimated Load (lb/day) [1]	1.2	1.3	0	0.46	0.21	0.17	0.16	0.088	0.091	0.10	0.24	0.12	4.1

1 Loads estimated assuming median concentration equals half the detection limit.

Groundwater, Atmospheric Deposition, and Sediment

For the purposes of estimating loads, groundwater seepage was assumed to equal any flow entering the surface water from the ground. This includes groundwater from defined aquifers and water passing through the top layers of the soil from irrigation, etc. and then being transported into the surface water system. Groundwater seepage loads were estimated using estimated groundwater flows as described in Section 1 and concentrations observed in groundwater monitoring. For the area of seepage upstream of Simi Valley, the water quality was assumed to be equal to the water quality monitored during the CCCS from the groundwater dewatering wells, and the median ammonia-N concentration was used. In the Thousand Oaks area, groundwater quality was based on groundwater monitoring conducted during the CCCS study. Although these data were collected from groundwater basins adjacent to those that actually would be seeping into the creek system, they are the only available ammonia groundwater data in the Thousand Oaks area. The flow rates for the groundwater were estimated using pumping flow rates for the Arroyo Simi and assumptions described in Section 1 for the Arroyo Conejo. Because the groundwater discharges in Simi are pumped, a significant seasonal variation in discharges is not expected. In the Thousand Oaks area, the impact of the rainy season on the discharge rates and concentrations of groundwater could not be evaluated based on the existing data. Because of the relatively low concentrations of ammonia in groundwater, seepage into the creek system contributes a relatively small amount of ammonia to the watershed. Table 2-11 summarizes the dry weather groundwater seepage concentrations and loads for each reach.

Ammonia is present in gaseous and particulate form in the atmosphere. In the clean troposphere, gaseous ammonia concentrations are approximately 1 ppb, but can be up to 10-25 ppb in areas with polluted air quality (Seinfeld, 1986). The majority of this ammonia serves to neutralize acidic pollutants in the atmosphere. It readily reacts with water vapor in the air to form the ammonium ion. Deposition of ammonia occurs primarily through precipitation, but dry deposition may contribute some ammonia directly to the creek system.

Atmospheric deposition as a source is defined as ammonia deposited directly to the creek surface. Ammonia deposited to land surface in the watershed is assumed to be accounted for by the loadings in runoff from the various land uses characterized above. Estimates of dry weather atmospheric loads of ammonia to the creek surface were based on deposition loads measured at a National Atmospheric Deposition Program monitoring site in Glendale (NADP, 2000). Deposition rates in kg per hectare per day were estimated for each season of the year based on samples collected at this site. To estimate deposition during dry weather, the average deposition rate calculated from data collected from 1982 through 1999 during the summer season (June through August) were used. The average deposition rate (0.0013 kg/hectare/day) was then multiplied by the estimated surface area of the reach to determine the estimated loadings of ammonia to the reach from atmospheric deposition. As shown in Table 2-11, these direct atmospheric loadings are insignificant compared to the other loads of ammonia in the watershed.

Sediment contributions of ammonia result primarily from degradation of organic matter and excretions from sediment dwelling organisms. The sediment itself does not contribute any ammonia to the water column. Sediment can potentially serve as a temporary sink for ammonia once equilibrium is established with other cations. Ammonia is held in the sediment by cation exchange reactions and converted to nitrate. When the nitrate is released, more ammonia can be absorbed into the sediment. These sediment reactions are basically a conversion process in the nitrogen cycle and not a separate source, and therefore these processes are accounted for in the characterization of the nitrogen cycle.

Table 2-11. Groundwater and Atmospheric Deposition Loads (lb/day)

Reach	Arroyo Simi Upper	Arroyo Simi/Las Posas	Dry Calleguas	Arroyo Conejo Upper	Arroyo Conejo Lower	Arroyo Santa Rosa	Conejo Creek Upper	Conejo Creek Lower	Calleguas Creek Upper	Calleguas Creek Lower	Revolon Slough	Mugu Lagoon
Groundwater												
Median Total Ammonia-N Concentration (mg/L)	0.32			0.04	0.04	0.04						
Estimated Flow (cfs)	2.3	0	0	1.5	0.96	0.90	0	0	0	0	0	0
Estimated Load (lb/day)	4.0	0	0	0.35	0.22	0.20	0	0	0	0	0	0
Atmospheric Deposition												
Deposition rate (kg/acre/day)	0.00053	0.00053		0.00053	0.00053	0.00053	0.00053	0.00053	0.00053	0.00053	0.00053	0.0005 3
Area of reach (acre)	31.3	75.5	0	20.6	2.8	5.6	21.7	5.7	12.3	113	67.7	29.9
Estimated Load (lb/day)	0.036	0.088	0	0.023	0.0032	0.006	0.025	0.007	0.014	0.13	0.077	0.034

Conversion of Other Nitrogen Compounds

Another “source” of ammonia is conversion of organic nitrogen to ammonia. Concentrations of organic nitrogen in the waterbody can be converted to ammonia. The amount contributed from this source will vary over time depending on the conditions in the waterbody and the amount of organic nitrogen in the water body. The amount of ammonia coming from organic nitrogen conversion was estimated by using the conversion rate of 1 per day assumed in the model. Organic nitrogen concentrations from the CCCS and Regional Board monitoring data in each reach were multiplied by the conversion rate and the travel time for the reach to estimate loads from this source.

Table 2-12. Estimated Conversion Loads from Organic Nitrogen to Ammonia

Reach	Estimated Conversion Load from Organic Nitrogen (lb/day)
Arroyo Simi Upper	15
Arroyo Simi/Las Posas	23
Dry Calleguas	0
Arroyo Conejo Upper	9
Arroyo Conejo Lower	1
Arroyo Santa Rosa	2
Conejo Creek Upper	7
Conejo Creek Lower	4
Calleguas Creek Upper	6
Calleguas Creek Lower	16
Revolon Slough and Ag Drains	28
Mugu Lagoon	2
Watershed Total	114

Conversion of organic nitrogen results in more ammonia loading to the waterbody than non-point sources of ammonia, but is relatively insignificant compared to POTW discharges of ammonia.

SUMMARY OF SOURCES OF AMMONIA LOADING

Although agriculture does contribute some additional loading during wet weather events, the large majority of the total annual load, 89%, is attributable to POTWs in the watershed. Annual loads from all the sources presented above were calculated to estimate the percentage of loading from each source during the year. Wet weather loads were estimated using the median wet weather ammonia-N concentrations observed during 205(j) and other stormwater monitoring in Ventura County. This value was multiplied by the amount of land use in the watershed, the runoff coefficient, and the estimated amount of average annual rainfall in the drainage area. Dry weather loads were assumed to occur on 350 days per year based on an average of 15 rain days per year in Ventura County (VCFCD, 1995). POTW and groundwater wet weather loads were calculated by assuming the same concentration with a 15% increase in flow for the day. Table 2-13 lists the median wet weather concentration from each land use and the associated runoff coefficient. Table 2-14 summarizes the estimated annual ammonia loadings in the watershed attributable to each source.

Table 2-13. Runoff Coefficients and Median Wet Weather Ammonia Concentrations in Runoff for Various Land Uses

Land Use	Median Wet Weather Ammonia-N Concentration in Runoff (mg/L)	Runoff Coefficient
Urban	0.3	0.58
Agriculture	0.63	0.26
Open Space	0.32	0.2

Table 2-14. Average Annual Loads of Ammonia in the Calleguas Creek Watershed

Source	lb/yr (dry)	% of Total Dry Load	lb/yr (wet)	Total Annual Load	% of Total Load	% of Land Use
POTWs	902,300	95%	44,471	946,771	89%	N/A
Agriculture	4,480	0.47%	22,711	27,191	3%	26%
Urban Runoff	1,540	0.16%	21,705	23,245	2%	24%
Open Space	1,470	0.15%	23,355	24,825	2%	50%
Groundwater	1,680	0.18%	83	1,763	0.17%	N/A
Atmospheric Deposition	140	0.01%	(1)	140	0.01%	N/A
Conversion	39,795	4.2%	(2)	39,795	3.7%	N/A
Watershed	951,405	100%	112,325	1,063,730	100%	100%

1 Wet weather deposition assumed to be included in the wet weather runoff from the various land uses.
2 Organic nitrogen conversion is likely to be less significant during wet weather events due to the higher velocities in the streams and disruption of bacteriological activities. Because of the lack of information about organic nitrogen conversion during wet weather, estimates of wet weather loadings could not be determined.

Existing and Maximum Allowable Concentrations

MAXIMUM ALLOWABLE RECEIVING WATER CONCENTRATIONS

The maximum allowable ammonia concentrations in the watershed are based on the 1999 criteria adjusted for site-specific conditions (i.e., multiplied by the WER). The chronic objective was calculated based on the average pH and temperature in the reach. Acute objectives were based on the 95th percentile pH and temperature in the reach. The actual maximum allowable concentrations will vary depending on the pH and temperature in the reach during the compliance period.

Table 2-15. Critical Condition Maximum Allowable Ammonia-N Concentrations

Reach	30-day Average Chronic Concentration (mg/L)[1]	1 hour Maximum Acute Concentration (mg/L)[1]
Arroyo Simi Upper	1.8 x WER	3.9 x WER
Arroyo Simi/Las Posas	2.7 x WER	8.4 x WER
Dry Calleguas	1.0 x WER	5.7 x WER
Arroyo Conejo Upper	1.7 x WER	3.2 x WER
Arroyo Conejo Lower	3.1 x WER	8.4 x WER
Arroyo Santa Rosa	2.4 x WER	5.7 x WER
Conejo Creek Upper	3.3 x WER	5.7 x WER
Conejo Creek Lower	3.5 x WER	4.1 x WER
Calleguas Creek Upper	2.7 x WER	2.7 x WER
Calleguas Creek Lower	2.2 x WER	2.7 x WER
Revolon Slough and Ag Drains	2.5 x WER	4.9 x WER
Mugu Lagoon	2.7 x WER	2.7 x WER

1 In the event a site specific WER has not been developed for a given reach, the WER for that reach will be set equal to 1.0.

CURRENT RECEIVING WATER CONCENTRATIONS

The current concentrations exceed the maximum pollutant concentrations by a significant amount. The average concentrations observed at monitoring locations within the reaches listed above were used for comparison to the maximum allowable chronic concentration. The 95th percentile concentrations were used for comparison to the maximum allowable acute concentration and are summarized below.

Table 2-16. Current Ammonia-N Concentrations

Reach	Average Concentration (mg/L)[1]	Maximum Allowable Chronic 30-day Average Concentration (mg/L)	95th Percentile Concentration (mg/L)	Maximum Allowable Acute 1-hour Concentration (mg/L)
Arroyo Simi Upper	0.33	1.8 x WER	0.88	3.9 x WER
Arroyo Simi/Las Posas	8.8	2.7 x WER	24.7	8.4 x WER
Dry Calleguas	2.3	1.0 x WER	3.9	5.7 x WER
Arroyo Conejo Upper	0.46	1.7 x WER	1.7	3.2 x WER
Arroyo Conejo Lower[2]	11.8	3.1 x WER	22.4	8.4 x WER
Arroyo Santa Rosa	0.19	2.4 x WER	0.45	5.7 x WER
Conejo Creek Upper[2]	7.8	3.3 x WER	14.2	5.7 x WER
Conejo Creek Lower[2]	6.2	3.5 x WER	15.2	4.1 x WER
Calleguas Creek Upper	5.3	2.7 x WER	10.7	2.7 x WER
Calleguas Creek Lower	3.7	2.2 x WER	10.0	2.7 x WER
Revolon Slough and Ag Drains	0.46	2.5 x WER	1.2	4.9 x WER
Mugu Lagoon	1.8	2.7 x WER	5.1	2.7 x WER

1 Non-detects were assumed to equal half the detection limit in the calculation of average concentrations.
2 Conejo Creek concentrations summarize monitoring conducted before Hill Canyon began nitrifying its effluent. Current concentrations are much lower (<0.01 to 1 mg/L-N).

For the reaches upstream of the Hill Canyon WWTP and Simi Valley WQCP and those to which no POTWs discharge (Revolon Slough), the current ammonia concentrations do not exceed the average maximum allowable ammonia concentrations.

In the Arroyo Simi/Las Posas reach, the current concentrations exceed the maximum allowable concentrations (assuming a WER of 1.0) by about 6.1-16.3 mg/L-N. Assuming a WER of 2.9, current concentrations in this reach exceed allowable concentrations by about 0.5-1.0 mg/L-N. This indicates that ammonia concentration reductions of between 10% and 70% will be needed to meet the ammonia target in the Arroyo Simi. Historically, the Conejo Creek system exceeded the maximum ammonia concentrations by 2.7-14.0 mg/L-N. Nitrification of Hill Canyon effluent has resulted in much lower concentrations of ammonia. NPDES monitoring conducted downstream of the Hill Canyon plant in 1999 demonstrated that ammonia objectives were met in five out of the eight months after Hill Canyon began nitrifying its effluent. The variability in the data resulted from the implementation of the nitrification processes which are impacted by the ongoing construction at the plant. After the construction is completed, Hill Canyon discharges should be able to continuously meet the ammonia target.

TMDL, Waste Load Allocations, and Load Allocations

WASTE LOAD ALLOCATIONS

Because POTWs are the most significant source of ammonia in the watershed, waste load allocations were determined for all POTWs in the watershed except Olsen Road. Olsen Road will be closed down within the implementation period for the ammonia TMDL. Consequently, there is no reason to require additional treatment for ammonia removal.

The waste load allocations for the POTWs were calculated based on the assumption that no dilution was available for the effluent. As a result, the wasteload allocations are equal to the ammonia target in the reach to which the POTW discharges. The following table summarizes the effluent limits and WLAs for each of the POTWs in the watershed.

Table 2-17. Ammonia Effluent Limits and WLAs[1]

POTW	Ammonia-N Daily Effluent Limit [2] (mg/L)	Ammonia-N Monthly Effluent [3] Limit (mg/L)	Daily WLA (lb/day) [4]	Monthly WLA (lb/day) [4]
Hill Canyon WWTP	8.4 x WER	3.1 x WER	8.4Q x WER	3.1Q x WER
Simi Valley WQCP	8.4 x WER	2.7 x WER	8.4Q x WER	2.7Q x WER
Moorpark WWTP	8.4 x WER	2.7 x WER	8.4Q x WER	2.7Q x WER
Camarillo WRP	4.1 x WER	3.5 x WER	4.2Q x WER	3.5Q x WER
Camrosa WWTP	2.7 x WER	2.2 x WER	2.7Q x WER	2.2Q x WER
Olsen Rd. WRP [5]	N/A	N/A	N/A	N/A

1 If a WER has not been developed for the downstream reach at the time the WLA is placed in a permit, the WER will be set equal to 1.0.
2 Acute effluent limits calculated based on the 95th percentile pH and temperature for the reach.
3 Chronic effluent limits calculated based on average pH and temperature for the reach.
4 WLA determined based on the target concentration times the discharge flow times the necessary conversion factors (Q). Because concentration is the target for the TMDL, the WLA will vary with the flow discharged from the POTW.
5 Olsen Rd. does not require an effluent limit because it will be shut down and its influent diverted to Hill Canyon for treatment.

As discussed earlier, the ammonia target is based on the pH and temperature of the receiving water. The intent of the effluent limits is to prevent an excursion in the receiving water above this target. However, because the pH and temperature in the receiving water is variable, the effluent limits need to be set to be sufficiently protective under a variety of receiving water conditions. The approach taken to determine these effluent limits was based on an examination of the pH and temperature in the waterbodies. Table 2-5 summarizes the pH and temperature characteristics of the reaches. In looking at the chronic objective, both temperature and pH need to be considered. For this reason, only data collected on the same day for both pH and temperature were used in the analysis. The acute criteria is only dependent on the pH of the waterbody, so all of the available pH data were used in the analysis. The pH and temperature were compared to other available data, such as dissolved oxygen, to assess whether any patterns or critical conditions could be observed that would need to be taken into account in the WLAs. The review of the data did not reveal any patterns in the pH and temperature of the water as compared to dissolved oxygen. However, it should be noted that there was only a small dataset of samples collected on the same day for all three constituents that could be used for comparison. The review did not indicate any critical conditions to be considered in the determination of the WLA. Because the chronic criteria is a 30-day average, the average pH and temperature in the waterbody was used to determine the WLA. For the acute criteria, a 95^{th} percentile pH was chosen.

The WER estimated from available receiving water characteristics is 2.9. Effluent limits and WLAs that would be required based on the estimated WER are presented in Table 2-18. These effluent limits represent the potential effluent limits that could result if an SSO is developed for the reaches impacted by the wastewater discharges. If a WER study is not conducted by the time the WLA is placed in a permit, the WER will be set equal to one, and the effluent limits will be equal to those presented in Table 2-17. Additionally, although a WER and SSO for ammonia may be developed for all reaches, as discussed in the algae/D.O. TMDL, some reaches may be required to reduce Total Kjeldahl Nitrogen (TKN) concentrations to address low dissolved oxygen levels. Because ammonia is a component of TKN, the higher effluent limits based on the protection of the aquatic life beneficial use from toxicity may not be appropriate for these reaches.

Table 2-18. Ammonia Effluent Limits and WLAs Based on the Estimated WER [1]

POTW	Ammonia-N Daily Effluent Limit [2] (mg/L)	Ammonia-N Monthly Effluent [3] Limit (mg/L)	Daily WLA (lb/day) [4]	Monthly WLA (lb/day) [4]
Hill Canyon	24.3	9.0	24.3Q	9.0Q
Simi Valley WQCP	24.3	7.8	24.3Q	7.8Q
Moorpark	24.3	7.8	24.3Q	7.8Q
Camarillo	12.2	10.2	12.2Q	10.2Q
Camrosa	7.8	6.4	7.8Q	6.4Q
Olsen Rd.[5]	N/A	N/A	N/A	N/A

1 WER is assumed to equal 2.9. Effluent limits estimated as equal to the 1999 updated criteria multiplied by the WER.
2 Acute effluent limits calculated based on the 95th percentile pH and temperature for the reach.
3 Chronic effluent limits calculated based on average pH and temperature for the reach.
4 WLA determined based on the target concentration times the discharge flow times the necessary conversion factors (Q). Because concentration is the target for the TMDL, the WLA will vary with the flow discharged from the POTW.
5 Olsen Rd. does not require an effluent limit because it will be shut down and its influent diverted to Hill Canyon for treatment.

NON-POINT SOURCE LOAD ALLOCATIONS

There are no demonstrated significant loads of ammonia from non-point sources in the watershed. At this time, no reductions in loadings for non-point sources are proposed. Should increases in non-point source concentrations be observed during future monitoring, load allocations for these sources will be developed at that time.

Margin of Safety, Seasonal Variations, and Future Growth

MARGIN OF SAFETY

The WLAs for the POTWs were set with the assumption that there is no dilution in the creek system for the discharged effluent. However, groundwater, agriculture, and urban runoff flows comprise approximately 20% of the baseline dry weather flow in the watershed. The ammonia loadings in this flow are less than 10% of the target load. The difference between the maximum load in the waterbody for this portion of the flow and the current load is considered to be the margin of safety for the TMDL. The estimated margin of safety is therefore in the vicinity of 18% of the TMDL for each reach of the waterbody under baseline conditions (depending on the proportion of non-POTW flow in the reach).

Because the margin of safety is based on an assumption of the amount of flow in the watershed, the actual margin of safety will vary depending on the actual flow and concentrations of flow found in the non-POTW discharges. The baseline flow outlined for this TMDL is the dry weather 30Q3 flow, or the average of the lowest flows occurring on 30 consecutive days during the dry season, with a return period of 3 years. This flow is equal to the 15-20th percentile mean daily flow in the watershed. This means that 80% of the time, the flow component of the margin of safety is greater than estimated above and 20% of the time it is lower. To quantify the flow component of the margin of safety during the 20% of the time that the flows are lower than the baseline, a number of flows representing percentiles below 20 were selected, and the margin of safety under these flow regimes was calculated. The following table summarizes these values.

Table 2-19. Estimated Margins of Safety under Different Flow Conditions

Percentile	Approximate Flow Represented by the Percentile flow[1]	Estimated MOS[2]
0.1	1Q10	2%
1	1Q3 and 7Q10	12%
5	7Q3 (Revolon, Conejo)	15%
10	7Q3 (Arroyo Simi, Calleguas)	18%

1 The actual percentile for each flow varies by the reach. The percentile for the 7Q3 flow varies the most, from the 3rd percentile in Revolon to the 10th percentile in the Arroyo Simi. As a result, both the 5th and 10th percentile calculations were included for comparison.

2 MOS estimated based on the associated percentile flows at VCFCD gage 803, upstream of Simi Valley WQCP. No other gages are available upstream of POTW discharges to allow for analysis.

As these calculations demonstrate, during the lowest flows observed in the watershed, the MOS is close to zero. However, for approximately 99% of the time, the flow component of the MOS is at least 10%.

When quantifying the margin of safety in this way, the variability of the upstream concentration data also needs to be taken into account. To assess the variability of the upstream concentration data, the actual receiving water concentrations from the reaches above the Simi Valley WQCP and above the Hill Canyon WWTP were examined. The following table summarizes the 90th, 95th, 99th, and 99.9th percentile concentrations in these reaches and the associated concentration margin of safety, and the overall MOS assuming that the 90th percentile concentration corresponds to the 10th percentile flow, the 95th percentile concentration corresponds to the 5th percentile flow, etc.

Table 2-20. Estimated Margins of Safety under Different Flow Conditions

Percentile	Ammonia-N Concentration Arroyo Simi Upper (mg/L)	Ammonia-N Concentration Arroyo Conejo Upper (mg/L)	Estimated Concentration MOS [1]	Estimated Total MOS
99.9	1	5.7	32-88%	0.6-1.8%
99	0.98	4	52-88%	6-11%
95	0.92	1.66	80-89%	12-13%
90	0.56	1.2	86-93%	15-17%

1 The estimated MOS is calculated based on the maximum allowable concentration in the reach downstream of Simi Valley and Hill Canyon (8.4 mg-N/L).

The overall margin of safety for this watershed will vary depending on the upstream concentration and the amount of flow in the watershed. Under worst case conditions, the margin of safety will be near zero. However, for at least 95% of the time, the margin of safety will be greater than 10% in all reaches of the watershed.

SEASONAL VARIATIONS

Because the primary source of ammonia is POTWs, the loading to the watershed is relatively constant throughout the year. Wet weather monitoring of urban runoff and agricultural areas indicates that wet weather runoff does not contain significantly higher concentrations than dry weather runoff (see Table 2-22). Increased flows during wet weather that do not contain large ammonia loads will serve to dilute loads coming from POTWs. Ammonia concentrations in the Calleguas Creek system should accordingly be lower during wet weather than during dry weather. Three of the twelve CCCS monitoring events were collected during a storm event. The average of the results from these events were compared to the average of the other nine events. The results, presented in Table 2-21, show that the wet weather average ammonia concentration was approximately equal to or lower than the dry weather ammonia concentration in all reaches. Table 2-22 shows the median wet weather concentrations in runoff from various land uses.

Table 2-21. Comparison of Wet and Dry Weather CCCS Receiving Water Data

Reach	Average Wet Weather Ammonia Concentration in Calleguas Creek Reach (mg/L)	Average Dry Weather Ammonia Concentration in Calleguas Creek Reach (mg/L)
Arroyo Simi Upper	0.43	0.45
Arroyo Simi Lower	4.30	7.41
Arroyo Santa Rosa [1]	0.23	0.18
Arroyo Conejo Upper	0.17	0.23
Arroyo Conejo Lower	6.33	11.5
Conejo Upper	4.91	9.03
Conejo Lower	3.37	5.63
Revolon	0.23	0.52
Mugu	0.62	0.61

1 The Arroyo Santa Rosa reach shows a higher concentration in wet weather due to the fact that most of the samples were non-detect for ammonia. One sample collected during a wet weather event was detected at a level higher than any observed during dry weather (0.5 mg/L vs. 0.4 mg/L). This resulted in a higher median value due to the limited number of wet weather samples. Although the wet weather median is slightly higher in this reach, the values are significantly below the maximum allowable concentration.

Table 2-22. Median Wet Weather Ammonia Concentrations in Runoff from Various Land Uses

Land Use	Median Wet Weather Ammonia-N Concentration in Runoff (mg/L)	Median Dry Weather Ammonia-N Concentration in Runoff (mg/L)
Urban	0.3	<0.2
Agriculture	0.63	0.24
Open Space	0.32	<0.2

The fact that wet weather concentrations observed in the waterbody are for the most part lower than those observed during dry weather, and non-point source contributions do not exceed the maximum allowable concentration during wet weather, indicates that the load allocations developed for dry weather conditions are sufficiently protective of wet weather conditions and no seasonal load allocations need to be developed.

FUTURE GROWTH

Over the past 30 years, rapid growth has been occurring in the Calleguas Creek watershed. Between 2000 and 2020, the population of Ventura County is expected to increase by 23% to 915,000 people (Ventura County Organization of Governments, 2000). This increase in population will likely increase the flows and loadings from the POTWs in the watershed. However, because the targets are concentrations and the WLAs are the target concentrations times the flows (and a conversion factor), the WLAs will accommodate future growth as long as the target concentrations are achieved (see Table 2-17).

Implementation Plan

An overall implementation plan for nutrients has been developed and is provided in Section 5 of this document. This implementation plan coordinates implementation actions for the ammonia, oxidized nitrogen, and algae/dissolved oxygen TMDLs. Implementation measures for the ammonia TMDL are included as part of this overall implementation plan.

Section 3. Oxidized Nitrogen TMDL

Introduction

Nitrogen is present in several forms in aquatic environments. Cycling between the various inorganic and organic forms of nitrogen makes it difficult to address any one of the forms separately from the others. In addition, nitrogen compounds have impacts on algae and dissolved oxygen levels in the watershed. For this reason, the TMDLs for all nitrogen compounds in the watershed, specifically ammonia-N; nitrate-N, nitrite-N, and nitrate-N+nitrite-N (oxidized nitrogen); and the associated algae/dissolved oxygen TMDL were developed at the same time. Introductory material describing the regulatory context of TMDLs, a description of the watershed, the total nitrogen budget for the watershed, and flow and modeling information common to all the nutrient TMDLs is presented in Section 1 of this nutrient TMDL document. This section presents the TMDL for nitrate-N, nitrite-N, and nitrate-N+nitrite-N (collectively called oxidized nitrogen compounds in this document), but is closely tied to and must be considered in the context of the other nutrient TMDLs.

Pollutant Identification and Applicable Standards

WATER QUALITY MONITORING AND 303(D) STATUS

Nitrate-N + nitrite-N and nitrogen are listed on the 1998 303(d) list as impairing various reaches of the Calleguas Creek watershed (SWRCB, 1999). Background information developed for the 1996 303(d) list indicates that nitrate-N + nitrite-N is listed as impairing drinking water and ground water recharge beneficial uses in Beardsley Channel, Revolon Slough, and Calleguas Creek and unknown beneficial uses in the Arroyo Las Posas. Nitrogen is listed as impairing aquatic life beneficial uses in Beardsley Channel, Revolon Slough, Calleguas Creek, Mugu Drain, Oxnard Drain #3, and Mugu Lagoon (RWQCB, 1996a). The specific nitrogen compounds that result in the nitrogen listings were not identified, so it is assumed the listings were based on measured nitrate-N and nitrite-N concentrations.

The 303(d) listing was based primarily on the data collected by the POTWs under their NPDES permits, the Thousand Oaks Study, and Regional Board monitoring. 303(d) listings were made on the basis of 14 reaches throughout the watershed. Monitoring stations within each of the reaches were used to determine whether or not the beneficial uses in the reach were impaired by oxidized nitrogen compounds. Exceedance of the drinking water objectives was determined if the median value in the data exceeded objectives. For the other objectives, if more than 40% of the samples collected at the monitoring stations in the reach exceeded the oxidized nitrogen objectives, the beneficial uses were considered to be impaired (RWQCB, 1996a).

Through these collection programs, 360 samples were collected at 61 stations throughout the watershed. The following table summarizes the water quality samples used as a basis for the 303(d) listings.

Table 3-1. Water Quality Results Used as Basis for 303(d) Listing for Oxidized Nitrogen

Reach	Number of Stations	Number of Samples	Mean (mg/L-N)	Median (mg/L-N)	Percent above Objective	Listing
Calleguas Creek R1 (Estuary to Broome Ranch Rd.)	3	29	14.8	15	76%	Nitrogen
Calleguas Creek R2 (Broome Ranch Rd. to Portrero Rd.)	2	26	14.1	11.7	73%	Nitrogen
Calleguas Creek R3 (Portrero to Lewis/Somis Rd.)	6	67	12.1	9.9	48%	Nitrate+Nitrite
Conejo Creek R1 (Confluence Calleguas to Santa Rosa Rd.)	8	60	11.0	8.1	33%	Not listed
Conejo Creek R2 (Santa Rosa Rd. to T.O. City Limit)	3	31	9.4	7.1	29%	Not listed
Conejo Creek R3 (T.O. City Limit to Lynn Rd.)	5	60	3.7	0	8%	Not listed
Conejo Creek R4 (Above Lynn Rd.)		No data				Not listed
Arroyo Santa Rosa Tributary		No data				Not listed
Arroyo Conejo North Fork	6	35	4.5	0	0%	Not listed
Arroyo Las Posas R1 and R2 (Lewis-Somis Rd. to Moorpark Fwy)	5	5	11.3	9.98	80%	Nitrate + Nitrite
Arroyo Simi R1 (Moorpark Fwy to Brea Canyon)	9	10	4.7	0	10%	Not listed
Arroyo Simi R2 (Above Brea Canyon)	3	7	3.3	3.6	0%	Not listed
Beardsley Wash/Channel	3	5	16.1	10.5	60%	Nitrogen
Revolon Slough	7	22	48.5	47.2	100%	Nitrogen
Duck Pond Ag Drain	1	3	79.6	67	100%	Nitrogen
Mugu Lagoon		No data				Nitrogen
Fox Barranca		No data				Nitrate + Nitrite
Long Canyon		No data				Nitrate + Nitrite

The monitoring conducted by the POTWs, the CCCS, and the Thousand Oaks Characterization Study subsequent to the 1996 and 1998 303(d) listing has confirmed the basis for most of these listings. Monitoring data from the CCCS and Thousand Oaks Study indicate that oxidized nitrogen objectives are not being exceeded upstream of the Hill Canyon WWTP or the Simi Valley WQCP. Oxidized nitrogen objectives are currently not exceeded downstream of POTWs unless they nitrify their effluent. Oxidized nitrogen objectives were exceeded in Revolon Slough, other agricultural areas, and Mugu Lagoon.

Water Quality Objectives

One purpose of the nitrate and nitrite objectives in the Basin Plan is to protect humans from health effects that can arise from ingestion of these compounds. Nitrate and nitrite concentrations in drinking water can cause methemoglobinemia in humans. Methemoglobinemia is a condition where the red blood cells are unable to carry oxygen throughout the body. Methemoglobinemia can result in cyanosis, weakness, rapid pulse, and, at high enough levels, death. In Ventura County, drinking water supplies contain concentrations of nitrate and nitrite well below this level, and there have been no reported incidents of methemoglobinemia resulting from ingestion of surface water from the creek system (Edrada, 2001). The objectives listed in the Basin Plan are designed to protect the most sensitive human population, infants. Infants generally have a higher intake of water per body mass than adults and may have higher pHs in their stomach that make them more susceptible to nitrite and nitrate concentrations (EPA, 1990).

Oxidized nitrogen objectives applicable to the Calleguas watershed are listed in the following three sections of the Basin Plan: for municipal drinking water supplies, for the LA Region, and for specific waterbodies in the region. The following table summarizes the Basin Plan objectives (RWQCB, 1994).

Table 3-2. Oxidized Nitrogen Objectives Applicable to the Watershed

Constituent	MUN Designated Waterbodies (mg/L)	Regional Objectives (mg/L)	Waterbody-Specific Objectives (above Portrero Rd.) (mg/L)
Nitrate as NO3	45	45	
Nitrate-N		10	
Nitrite-N	1	1	
Nitrate-N+Nitrite-N	10	10	
Nitrogen (Nitrate-N + Nitrite-N)			10

The MUN designated waterbody objectives and the waterbody-specific objectives apply to a subset of the Calleguas watershed. The regional objectives apply to all reaches of the Calleguas Creek system.

In addition to the numeric objectives for nitrate, nitrite, and nitrate + nitrite listed in the Basin Plan, a narrative objective for biostimulatory substances is also included in the Basin Plan:

> "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."

Because nitrate and nitrite are bioavailable forms of nitrogen which aquatic plants use in their growth, the narrative standard for biostimulatory substances is also applicable to nitrate and nitrite.

Numeric Targets

DEFINITION OF TARGETS

The purpose of TMDLs is to protect beneficial uses. As such, the targets of the TMDL are the values that will result in protection of the beneficial uses. The targets may be the numeric water quality objectives that have been set for the watershed or may be based on other targets determined to be sufficient to protect beneficial uses in the watershed.

For oxidized nitrogen compounds, the beneficial uses to be protected are municipal supply, groundwater recharge, and recreation and aquatic life (from biostimulatory impacts). The objectives presented in the Basin Plan are listed to protect all of these uses, but they are based on criteria developed by the EPA to protect human health from drinking water contaminated with oxidized nitrogen compounds. In the Calleguas Creek watershed, municipal supply (MUN) is listed as a potential beneficial use. However, this beneficial use is based on the State Board's "Sources of Drinking Water Policy" which states that all waterbodies in California must be listed as potential municipal supplies unless they qualify for one of the listed exemptions or studies determine this use to be infeasible. Currently, there is no existing or planned use of the Calleguas Creek surface water for municipal supply.

Groundwater in the Calleguas Creek watershed is currently used as municipal supply. Groundwater recharge occurs in several reaches of the watershed. Groundwater used as a municipal supply that is recharged by surface water is required to meet drinking water standards regardless of the beneficial uses of the surface water. This use is protected under the groundwater recharge (GWR) beneficial use, not the MUN beneficial use. The extent to which oxidized nitrogen concentrations in surface water are impacting oxidized nitrogen concentrations in groundwater is unclear in most regions of the watershed. On Beardsley Wash, near Central Ave., groundwater monitoring has revealed an increased concentration of oxidized nitrogen in the vicinity of the Slough. This indicates that high oxidized nitrogen concentrations in Beardsley Wash are increasing the concentrations of oxidized nitrogen in the vicinity of the wash (Bachman, 2001b). Additionally, elevated concentrations of nitrate are evident in several areas of the Las Posas basin. Of these areas, one borders Arroyo Las Posas, where nitrate levels above drinking water standards are consistently sampled from shallow groundwater wells adjacent to the arroyo (Bachman, 2001a). Preliminary indications from groundwater monitoring conducted during the CCCS indicate that nitrate concentrations in surface water do have some impact on groundwater concentrations of nitrate, but not all of the surface water nitrate ends up in the groundwater. There appears to be some attenuation of the nitrate concentrations in the vadose zone, but additional research is needed to quantify the amount of nitrate that reaches the groundwater from surface water recharge.

Finally, the oxidized nitrogen criteria necessary to prevent beneficial use impacts from aquatic growth, primarily algae, are difficult to quantify. As discussed in the algae TMDL, the aquatic life beneficial use is expected to be protected by dissolved oxygen targets. However, further monitoring of algal biomass and impacts may demonstrate that oxidized nitrogen objectives more stringent than those in the Basin Plan are required to protect recreational beneficial uses.

To meet existing water quality standards, the TMDL will be developed based on targets equal to the objectives presented in the Basin Plan. Based on current information, these targets are considered protective of the designated beneficial uses in the watershed. However, existing uncertainties regarding the municipal water supply use and a lack of data about algae and groundwater impacts mean that modifications to these targets may be required based on future monitoring and/or beneficial use modifications in the watershed. These modifications could result in targets that are more or less stringent than the targets presented in this document.

Even though there are multiple objectives for oxidized nitrogen compounds listed in the Basin Plan, they all correspond to the same values in the Calleguas watershed. The targets for the TMDL are set for oxidized nitrogen compounds as nitrogen (nitrate-N and nitrite-N). Nitrate as NO_3 measurements can be easily converted to nitrate-N for comparison with the target by using a conversion factor of 4.5. Based on the analysis for the biostimulatory narrative standard described in the TMDL for algae/dissolved oxygen, there is no indication at this time that oxidized nitrogen levels lower than the Basin Plan objectives are required to meet the biostimulatory narrative standard. The following table summarizes the oxidized nitrogen targets for the Calleguas watershed.

Table 3-3. Total Nitrate-N and Nitrite-N Targets

Reach	Nitrate-N	Nitrite-N	Nitrate-N + Nitrite-N
Upper Arroyo Simi	10	1	10
Arroyo Simi/Las Posas	10	1	10
Dry Calleguas	10	1	10
Upper Arroyo Conejo	10	1	10
Lower Arroyo Conejo	10	1	10
Arroyo Santa Rosa	10	1	10
Conejo Creek Upper	10	1	10
Conejo Creek Lower	10	1	10
Calleguas Creek Upper	10	1	10
Calleguas Creek Lower	10	1	10
Revolon Slough and Ag Drains	10	1	10
Mugu Lagoon	10	1	10

Nitrate and nitrite toxicity is a function of concentration, not load in the waterbody. When water is used for drinking water, the concentration of nitrate and nitrite in the water that is delivered to the public is the concern. The total load in the waterbody will not impact the individual drinking the water.

There is some concern about the potential for nitrogen "build-up" in groundwater and Mugu Lagoon. As discussed in the introduction, the volume of water entering the lagoon from the Calleguas watershed is a small fraction of the volume of the tidal prism for Mugu Lagoon. Because oxidized nitrogen is primarily present in dissolved form in the watershed, a build-up of nitrogen in the lagoon is unlikely. However, there is currently no information available about the impacts of oxidized nitrogen in the lagoon. As part of the implementation plan, this issue will be investigated further.

Elevated concentrations of nitrate in groundwater were observed in some areas during the Calleguas Creek Characterization Study monitoring. In a study conducted in Michigan to assess the impacts of urban areas on groundwater, a threshold of 2 mg/L of nitrate was used to distinguish between wells impacted by anthropogenic activities and those that were not impacted (Thomas, 2000). Although this threshold was developed based on the examination of historical data in that region, it is used here for comparison purposes. Using the 2 mg/L threshold, 50% of the wells monitored in the Calleguas Creek watershed have elevated nitrate levels. Five out of twenty-four monitored wells have average nitrate concentrations that exceed the drinking water standard of 10 mg/L. In the Santa Rosa Valley, where septic tanks are a potential contributor of nitrate, all wells show elevated nitrate levels. The other wells are scattered throughout the watershed with the highest nitrate levels showing up at the well just upgradient of the Moorpark WWTP (Navigant, 2000). Although there is evidence of elevated nitrate levels in some groundwater basins, identifying the sources of the elevated nitrate concentrations is difficult. Investigations into groundwater nitrate concentrations have shown that pockets of elevated nitrate concentrations in groundwater move from area to area in the basin. A well may demonstrate elevated nitrate concentrations one year and not the next year (Bachman, 2001a). In some areas, such as Beardsley Wash near Central Ave., there appears to be a direct connection between elevated surface water concentrations of nitrate and elevated groundwater nitrate concentrations. In other areas, such as the Arroyo Las Posas where pockets of elevated nitrates move throughout the basin, impacts from surface water are less clearly defined (Bachman, 2001b).

As discussed in the Michigan paper, most of the impacts to groundwater in that region came from direct infiltration from lawns or septic tanks. In the Forebay of the Oxnard Plain basin (El Rio area), persistent elevated nitrate levels have been observed in the groundwater. The Regional Water Quality Control Board determined that both septic systems and irrigation return flow were contributing to the nitrate concentrations (Bachman, 2001b). The Regional Board proposed - and in 2001 the

State Water Resources Control Board adopted - a ban on septic systems in the Forebay to force a solution to the contamination. Therefore, the elevated concentrations in groundwater could result from watershed activities that are not connected to the surface water and would need to be addressed through other mechanisms than this TMDL.

Further investigation of groundwater and Mugu impacts may result in requirements for oxidized nitrogen loadings in addition to the oxidized nitrogen concentrations. However, there is insufficient information at this time to make that requirement. As a result, the TMDL will be based on the concentration targets presented in Table 3-3 rather than a pollutant load. Wasteload and load allocations are based on the concentration targets multiplied by the discharge flows and a conversion factor (Q).

Source Identification

POTWS

Seven wastewater treatment plants have operated in the watershed. Nyeland Acres was phased out of operation in December, 1998. Camrosa and Moorpark Water Reclamation Plants reclaim most of their effluent for use in agriculture or infiltrate their discharge in percolation ponds. Only during wet, winter months do either of the plants discharge effluent to the receiving waters. Camarillo, Hill Canyon, Olsen Rd. and Simi Valley discharge year round to the Conejo, Arroyo Conejo, Arroyo Santa Rosa and Arroyo Simi, respectively. The following table summarizes the POTWs in the watershed, their design flows, receiving waters, and the population served.

Table 3-4. POTW Descriptions

POTW	Current Design Capacity (mgd)	Receiving water	Population Served [1]
Hill Canyon Wastewater Treatment Plant	10.8	North Fork Arroyo Conejo	100000
City of Simi Valley Water Quality Control Facility	12.5	Arroyo Simi	101830
Camarillo Sanitary District, Water Reclamation Plant	6.75	Conejo Creek	40,600
Moorpark Wastewater Treatment Plant	2	Arroyo Las Posas	26932
Camrosa Wastewater Treatment Plant	1.5	Calleguas Creek during wet season	24,000[2]
Olsen Road Water Reclamation Plant	0.75	Arroyo Santa Rosa	7500

1 Estimated population served from Bookman Edmonston, 1997.
2 Information from Camrosa website (www.camrosa.com).

In May 1999, the City of Thousand Oaks began experimenting with nitrification and denitrification at the Hill Canyon WWTP. The City is still working out the details of the processes but still continuously nitrifies and denitrifies all of its effluent. Moorpark is currently expanding their plant to allow for more reclamation and percolation of the treated wastewater to avoid discharging to the Arroyo Las Posas. As part of this expansion, nitrification and denitrification facilities are being built that will provide treatment to any effluent discharged to the creek. Camarillo currently nitrifies, but does not denitrify its effluent. Simi

Valley has no nitrification or denitrification facilities in place. Wastewater treated by Olsen Road will be transported to Hill Canyon within the next five years, and the plant will be phased out of operation.

POTWs that do not nitrify their effluent generally discharge relatively low levels of nitrate and nitrite. If the plant nitrifies but does not denitrify its effluent, the discharged nitrate concentrations increase significantly. Because of the various treatment processes employed by the POTWs in the watershed, nitrate and nitrite concentrations and loadings vary significantly from plant to plant. Table 3-5 characterizes the nitrate and nitrite discharges from each of the POTWs. The average concentrations were calculated from the CCCS data.

Table 3-5. Oxidized Nitrogen Concentrations and Loads from POTWs

POTW	Average Flow (cfs)	Average Total Nitrate-N (mg/L)	Average Total Nitrite-N (mg/L)	Average Nitrate-N Load (lb/day)	Average Nitrite-N Load (lb/day)
Hill Canyon WWTP[1]	14	7.8	0.96	589	73
Simi Valley WQCP	14	1.68	0.39	127	22
Camarillo WRP	3.2	28.5	0.18	493	3.1
Moorpark WWTP	2	0.18	0.045	1.9	0.5
Olsen Rd. WRP	0.3	2.5	0.045	1.7	0.08

1 Hill Canyon concentration determined from the values reported in their 1999 annual report after nitrification was implemented.

OTHER SOURCES

Although POTWs can contribute a significant load of oxidized nitrogen compounds to the watershed, other sources of nitrate and nitrite are also significant. Identification of these sources and quantification of the loads from these sources were estimated based on the assumptions used to develop a simple mass load spreadsheet model to characterize nitrogen compounds in the watershed. Concentrations in runoff from each source and estimated flows were used to approximate loads from the other known sources in the watershed (See description of model and assumptions in Section 1).

Urban and Agricultural Sources

Through the use of fertilizers and septic tanks, both agriculture and urban areas contribute oxidized nitrogen to the watershed. In the Calleguas watershed, a variety of agricultural crops, irrigation practices, and drainage patterns result in the discharge of varying amounts of oxidized nitrogen. Currently, there is insufficient information to accurately quantify the contributions from different types of crops and different areas of the watershed. However, several general statements can be made.

In general, row crops are present in the valleys and flatter areas of the watershed and tree crops are grown in the hillier areas. The row crops are harvested several times during the year, and several different types of crops can be grown on the same plot of land during different times of the year. Row crops require less water per acre than tree crops, but they also receive more intense fertilization (McIntyre, 2001). Irrigation rates are generally similar across farms for a given type of crop. Along Revolon Slough, tile drains are employed to facilitate drainage in areas where the Oxnard Pressure Plain prevents infiltration of excess irrigation water. Tile drains are generally not present in other areas of the watershed, though one farm along Conejo Creek uses a tile drain. It is possible that tile drains could result in higher oxidized nitrogen discharges to the creek system, but there is no evidence of this currently available.

EPA developed a document to address agricultural sources of pollutants to surface and groundwater (EPA, 2000c). The document does not provide information about the concentrations of oxidized nitrogen discharged from different types of agriculture, but it does provide estimates of the nitrogen removal rates by crop. These rates are summarized in the following table.

Table 3-6. Crop Nutrient Removal

Crop	Yield/ac	Nitrogen Removal (lb/ac)
Corn	125 bu	95
Corn silage	21 t	190
Grain sorghum	125 bu	65
Soybeans	40 bu	130
Wheat/rye	60 bu	90
Oats	80 bu	90
Barley	75 bu	105
Alfalfa	5 t	250
Orchard grass	6 t	300
Tall fescue	2.5 t	135
Sugar beets	30 t	275

Although some information exists about the different agricultural practices in the watershed and different nutrient removal rates by different crops, there is no information that allows for the adequate characterization of oxidized nitrogen discharges from different types of agriculture. For this reason, a general agricultural loading is estimated for the watershed. The implementation plan for the TMDL recognizes that different types of agriculture will require different loading reductions and Best Management Practices (BMPs) to meet the load allocations for agriculture in the watershed.

Oxidized nitrogen discharges from urban areas were also assessed. Lawn fertilizers and septic tanks are potential sources of oxidized nitrogen from urban areas. In the Calleguas watershed, only a few areas remain where septic tanks are still used. The largest area of septic tank use is concentrated in the Santa Rosa Valley. Although septic tanks are likely to have an impact on groundwater concentrations of oxidized nitrogen, insufficient data is available on the potential discharges from septic tanks to surface water. Work being conducted under the Calleguas Characterization Study is looking into this connection. The study conducted in Michigan demonstrated that shallow groundwater beneath urban areas had significantly higher nitrate concentrations than groundwater not impacted by urban development (Thomas, 2000). However, the study could not distinguish between septic tank contributions and fertilizer contributions to the groundwater. Additionally, the study did not provide any information about discharges of nitrate to surface water.

For these reasons, septic tank contributions are considered to be accounted for in the concentrations from groundwater discharges to the surface water in the next section. The only information available about discharges of oxidized nitrogen from urban areas due to fertilizers or other sources comes from the 205(j) and Ventura County Stormwater Management Program monitoring data. As a result, these data are used to estimate the oxidized nitrogen loadings from urban areas.

Surface runoff loads were estimated based on land use category: urban, agriculture, and open space. For each land use category, median concentrations observed in dry weather runoff during the 205(j) monitoring were used as the basis for calculating loads. Flow estimates were not consistently collected during the 205(j) monitoring, making it difficult to directly calculate non-point source loads based on these data alone. As a result, load estimates were made based on the flow estimations presented in the model (See Section 1). Table 3-7 summarizes the estimated concentrations, flows, and loads by land use for each reach.

Table 3-7. Nitrate-N + Nitrite-N Concentrations and Loads from Surface Runoff

Reach	Arroyo Simi Upper	Arroyo Simi/Las Posas	Dry Calleguas	Arroyo Conejo Upper	Arroyo Conejo Lower	Arroyo Santa Rosa	Conejo Creek Upper	Conejo Creek Lower	Calleguas Creek Upper	Calleguas Creek Lower	Revolon Slough	Mugu Lagoon	Watershed
Urban Dry Weather													
Median N+N Concentration (mg/L)	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	
Estimated Flow (cfs)	1.7	1.3	0	1.8	0.92	0.31	0.35	0.077	0.010	0.025	1.4	0.39	
Estimated Load (lb/day) [1]	3.5	2.6	0	3.8	1.9	0.64	0.73	0.16	0.021	0.052	2.9	0.81	17.1
Agriculture Dry Weather													
Median N+N Concentration (mg/L)	32	32	32	32	32	32	32	32	32	32	32	32	
Estimated Flow (cfs)	0.0080	2.8	0	0	0.39	0.29	0.39	0.14	0.15	0.47	4.9	0.25	
Estimated Load (lb/day)	1.4	500	0	0	69	51	69	24	26	83	870	43	1736
Open Space Dry Weather													
Median N+N Concentration (mg/L)	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	
Estimated Flow (cfs)	2.3	2.5	0	0.84	0.38	0.31	0.30	0.16	0.17	0.19	0.44	0.23	
Estimated Load (lb/day) [1]	4.0	4.4	0	1.5	0.67	0.54	0.52	0.29	0.29	0.32	0.76	0.40	13.7

1 Loads estimated assuming median concentration equals half the detection limit.

As shown in Table 3-7, the loading from agriculture represents a significant component of the oxidized nitrogen loading in the watershed. However, the average loading presented in the table does not account for all of the oxidized nitrogen in Revolon Slough, nor does it differentiate between different nitrogen loadings from different agricultural crops and activities. To account for the concentrations observed during the CCCS in Revolon Slough, approximately 600 pounds per day of additional nitrate would need to be in the system. At the assumed flows, this additional load would result from a concentration of approximately 50 mg/L nitrate-N being discharged from agricultural areas. This concentration is approximately equal to the 80th percentile of the data obtained during the 205(j) and CCCS monitoring of agricultural discharges. However, the monitoring data does show that high levels of nitrates were found at almost all of the 205(j) monitoring locations. Of the six agricultural monitoring locations for which dry weather samples were collected, five of the stations had at least one of the two dry weather data points that exceeded 50 mg/L-N, and they all occurred during the May sampling event. The monitoring data collected during the CCCS at two agricultural discharge locations for a period of a year did not contain levels higher than 50 mg/L-N in any of the samples. Therefore, there appears to be areas of the watershed that receive agricultural discharges in excess of 50 mg/L-N, but additional monitoring is needed to determine where these areas are and how often nitrate discharges at these levels occur. These results indicate that it is not unreasonable that agricultural loads of this magnitude could be discharged in the watershed. However, at this time, the loadings presented above represent the best available estimate of agricultural loadings. Additional investigation and monitoring may be required to more accurately quantify these loadings.

Groundwater, Atmospheric Deposition, and Sediment

For the purposes of estimating loads, groundwater seepage was assumed to equal any flow entering the surface water from the ground. This includes groundwater from defined aquifers and water passing through the top layers of the soil from irrigation, etc. and then being transported directly into the surface water system. Groundwater seepage loads were estimated using groundwater flows estimated as described in Section 1 and concentrations observed in groundwater monitoring. For the area of seepage upstream of Simi Valley, the water quality was assumed to be equal to the water quality monitored during the CCCS from the groundwater dewatering wells, and the median nitrate-N and nitrite-N concentrations were used. In the Thousand Oaks area, groundwater quality was based on groundwater monitoring conducted during the CCCS study and a USGS groundwater study (USGS, 1980). The USGS study data were used for concentrations of nitrate in groundwater in the Thousand Oaks area. Because this report did not include nitrite data, the CCCS groundwater monitoring data were reviewed for nitrite concentrations. Although these data were collected from groundwater basins adjacent to those that actually would be seeping into the creek system, they are the only available nitrite groundwater data in the Thousand Oaks area. Nitrite was only detected in two samples out of twenty-eight at seven different wells. The detected concentrations (0.11 and 0.22 mg/L-N), were only slightly above the method detection limit (MDL 0.1 mg/L-N). As a result, nitrite concentrations in groundwater were assumed to be equal to half the detection limit. The flow rates for the groundwater were estimated using pumping flow rates for the Arroyo Simi and assumptions described in Section 1 for the Arroyo Conejo. Because the groundwater discharges in Simi are pumped, a significant seasonal variation in discharges is not expected. In the Thousand Oaks area, the impact of the rainy season on the discharge rates and concentrations of groundwater could not be evaluated based on the existing data. Table 3-8 summarizes the groundwater seepage concentrations and loads for each reach estimated for dry weather conditions.

Atmospheric deposition as a source is defined as oxidized nitrogen compounds deposited directly to the creek surface. Oxidized nitrogen deposited to land surface in the watershed is assumed to be accounted for by the loadings in runoff from the various land uses characterized above. Estimates of dry weather atmospheric loads of nitrate were based on deposition loads measured at a National Atmospheric Deposition Program monitoring site in Glendale (NADP, 2000). Deposition rates in kg per hectare per day were estimated for each season of the year based on samples collected at this site. To estimate deposition during dry weather, the average deposition rate calculated from data collected from 1982 through 1999 during the summer season (June through August) was used. The average deposition rate (0.0075 kg/hectare/day) was then multiplied by the estimated surface area of the reach to determine the estimated loadings of nitrate to the reach from atmospheric deposition. Nitrite is not commonly found in the atmosphere so the deposition of nitrite was assumed to equal zero. As shown in Table 3-8, these direct atmospheric loadings are insignificant compared to the other loads of nitrate in the watershed.

Sediment contributions of nitrate and nitrite result primarily from conversion of ammonia by sediment dwelling organisms. The sediment itself does not contribute any oxidized nitrogen compounds to the water column. Because these sources of oxidized nitrogen compounds are basically a conversion process in the nitrogen cycle and not a separate source, these processes are accounted for in the characterization of the nitrogen cycle.

Table 3-8. Groundwater and Atmospheric Deposition Loads of Nitrate and Nitrite (lb/day)

Reach	Arroyo Simi Upper	Arroyo Simi/Las Posas	Dry Calleguas	Arroyo Conejo Upper	Arroyo Conejo Lower	Arroyo Santa Rosa	Conejo Creek Upper	Conejo Creek Lower	Calleguas Creek Upper	Calleguas Creek Lower	Revolon Slough	Mugu Lagoon
Groundwater												
Median Nitrate-N Concentration (mg/L)	3.7	3.7		6.5	6.5	6.5						
Estimated Flow (cfs)	2.3	0	0	1.5	0.96	0.90	0	0	0	0	0	0
Estimated Load (lb/day)	46	0	0	53	34	32	0	0	0	0	0	0
Groundwater												
Median Nitrite-N Concentration (mg/L)	0.10			0.050	0.050	0.050						
Estimated Flow (cfs)	2.3	0	0	1.5	0.96	0.90	0	0	0	0	0	0
Estimated Load (lb/day)	1.2	0	0	0.42	0.26	0.24	0	0	0	0	0	0
Atmospheric Deposition												
Deposition Rate (kg/acre/day)	0.003	0.003		0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Area of reach (acre)	31.3	75.5	0	20.6	2.8	5.6	21.7	5.7	12.3	113	67.7	29.9
Estimated Nitrate Load (lb/day)	0.21	0.52	0	0.14	0.019	0.038	0.15	0.038	0.082	0.76	0.45	0.20

Conversion of Other Nitrogen Compounds

Another “source” of oxidized nitrogen compounds is the conversion of organic nitrogen and ammonia to nitrite and nitrate. Concentrations of organic nitrogen are converted to ammonia, which is then converted to nitrite. Nitrite is usually rapidly converted to nitrate in the waterbody. The amount contributed from this source will vary over time depending on the conditions in the waterbody and the concentrations of the various nitrogen compounds in the water body. The concentration increase of oxidized nitrogen resulting from organic nitrogen and ammonia conversion was estimated by using the conversion rate constants of 1 per day and 1.5 per day, respectively, assumed in the model. Organic nitrogen and ammonia concentrations from the CCCS and Regional Board monitoring in each reach were multiplied by the conversion rate and the travel time for the reach to estimate loads from this source.

Table 3-9. Estimated Conversion Loads from Ammonia and Organic Nitrogen to Oxidized Nitrogen

Reach	Estimated Conversion Load from Ammonia and Organic Nitrogen (lb/day)
Arroyo Simi Upper	17
Arroyo Simi/Las Posas	409
Dry Calleguas	0
Arroyo Conejo Upper	9
Arroyo Conejo Lower	51
Arroyo Santa Rosa	3
Conejo Creek Upper	276
Conejo Creek Lower	63
Calleguas Creek Upper	92
Calleguas Creek Lower	210
Revolon Slough and Ag Drains	35
Mugu Lagoon	14
Watershed Total	1179

As shown in the table above, discharges of ammonia and, to a certain extent, organic nitrogen in the watershed result in a significant load of oxidized nitrogen during dry weather. Although currently significant, the discharges of ammonia, and the resulting conversion of ammonia to oxidized nitrogen, will be significantly reduced through implementation of the ammonia TMDL. Implementation of the ammonia TMDL will result in at least a 50% reduction in the ammonia loads that are converted to oxidized nitrogen, based on the daily maximum effluent limits. The average reductions are likely to be closer to 80% in order for the POTWs to meet the 30-day average Waste Load Allocations described in the ammonia TMDL.

SUMMARY OF SOURCES OF OXIDIZED NITROGEN LOADING

In summary, a variety of sources contribute to the oxidized nitrogen loading in the watershed. Annual loads from all the sources presented above were calculated to estimate the percentage of loading from each source during the year. Wet weather loads were estimated using the mean wet weather nitrite-N + nitrate-N concentrations observed during 205(j) and other stormwater monitoring in Ventura County. This value was multiplied by the amount of land use in the watershed, the runoff coefficient, and the estimated amount of average annual rainfall in the drainage area. Dry weather loads were assumed to occur on 350 days per year based on an average of 15 rain days per year in Ventura County (VCFCD, 1994a). POTW and groundwater wet weather loads were calculated by assuming the same concentration with a 15% increase in flow for the day. Table 3-10 lists the median wet weather concentration from each land use and the associated runoff coefficient. Table 3-11 summarizes the estimated annual oxidized nitrogen loadings in the watershed attributable to each source.

Table 3-10. Runoff Coefficients and Mean Wet Weather Nitrate and Nitrite Concentrations in Runoff for Various Land Uses

Land Use	Mean Wet Total Nitrate-N + Nitrite-N Concentration (mg/L)	Runoff Coefficient
Urban	1.4	0.58
Agriculture	20.9	0.26
Open Space	0.67	0.2

Table 3-11. Average Annual Loads of Nitrate-N +Nitrite-N in the Calleguas Creek Watershed

Source	lb/yr (dry)	% of Total Dry Load	lb/yr (wet)	Total Annual Load	% of Total Load	% of Land Use
POTWs	458,948	30%	22,620	481,568	19%	N/A
Agriculture	605,601	39%	753,421	1,359,022	55%	26%
Urban Runoff	5,987	0.4%	101,291	107,278	4%	24%
Open Space	4,778	0.3%	48,535	53,313	2%	50%
Groundwater	58,656	4%	2,891	61,547	2%	N/A
Atmospheric Deposition	913	0.1%	(1)	913	0.04%	N/A
Conversion from Ammonia and Organic Nitrogen	412,633	27%	(2)	412,633	17%	N/A
Total for Watershed	1,547,516	100%	928,758	2,476,274	100%	100%

1 Wet weather atmospheric deposition is assumed to be accounted for in runoff from the various land uses.
2 Ammonia and organic nitrogen conversion during wet weather will likely be significantly reduced due to increased velocities in the system and disruption of the bacteriological community in the river. Because of the lack of information about the conversion rates of ammonia during wet weather, wet weather loads could not be estimated.

During dry weather, POTWs and agriculture contribute similar amounts of oxidized nitrogen to the watershed, but overall, agriculture accounts for 55% of the oxidized nitrogen loading and POTWs contribute 19%. If the conversion of ammonia discharges from POTWs to oxidized nitrogen are taken into account, POTWs contribute approximately 36% of the total annual oxidized nitrogen loading in the watershed. Wet weather accounts for approximately 38% of the total average annual oxidized nitrogen loading in the watershed.

Existing and Maximum Allowable Concentrations

MAXIMUM ALLOWABLE RECEIVING WATER CONCENTRATIONS

The maximum allowable pollutant concentrations for the watershed are based on the targets in Table 3-3. Loads are estimated based on current baseline flows in each reach. At any given point in the watershed, the maximum allowable pollutant load is equal to the maximum allowable concentration multiplied by the flow and a conversion factor. However, flows, infiltration rates, algal growth rates, and uses of the water all vary based on the season, time of day, temperature, and type of water year (drought vs. wet years). These variables affect the target concentration and the maximum allowable pollutant load.

For oxidized nitrogen compounds, Calleguas Creek, Beardsley Wash, Revolon Slough, and Arroyo Las Posas are the only reaches listed on the 303(d) list. In determining targets for the reaches not listed on the 303(d) list, it is important to consider the impact of these reaches on the downstream, listed reaches and the applicable beneficial uses in these reaches. Because oxidized nitrogen compounds will only become an issue in these reaches in response to potential implementation activities conducted for the ammonia TMDL, the maximum loads presented here are based on the existing situation and may change in response to future conditions.

The current critical condition maximum allowable oxidized nitrogen loads in the watershed are presented in the following table.

Table 3-12. Current Critical Condition Maximum Allowable Nitrate-N and Nitrite-N Concentrations and Loadings

Reach	Nitrate-N Concentration (mg/L)	Nitrate-N Load (lb/day)[1]	Nitrite-N Concentration (mg/L)	Nitrite-N Load (lb/day)[1]	Nitrate-N + Nitrite-N Concentration (mg/L)	Nitrate-N + Nitrite-N Load (lb/day)[1]
Arroyo Simi Upper	10	210	1	21	10	210
Arroyo Simi/Las Posas	10	971	1	97	10	971
Dry Calleguas	10	0	1	0	10	0
Arroyo Conejo Upper	10	216	1	22	10	216
Arroyo Conejo Lower	10	971	1	97	10	971
Arroyo Santa Rosa	10	54	1	5	10	54
Conejo Creek Upper	10	755	1	76	10	755
Conejo Creek Lower	10	647	1	65	10	647
Calleguas Creek Upper	10	593	1	59	10	593
Calleguas Creek Lower	10	647	1	65	10	647
Revolon Slough and Ag Drains	10	281	1	28	10	281
Mugu Lagoon [2]	10	5347	1	535	10	5347

1 Loads are presented for information and comparison purposes only. The loads were calculated based on the baseline flows presented in Table 1-5 and will vary based on the actual flows present in the reaches.
2 Loads for Mugu Lagoon represent the total loading from the watershed to the lagoon.

CURRENT RECEIVING WATER CONCENTRATIONS

The current concentrations and loads exceed the maximum allowable pollutant concentrations and loads in the Arroyo Las Posas, Calleguas Creek and Revolon Slough and other agricultural drains. Using the same average flows that were used to define the maximum pollutant loads and the average concentrations observed at monitoring locations within the reaches listed above, the current loads are summarized below.

Table 3-13. Current Oxidized Nitrogen Loadings

Reach	Average Nitrate-N Concentration (mg/L) [1]	Average Nitrate-N Load (lb/day)[3]	Average Nitrite-N Concentration (mg/L) [1]	Average Nitrite-N Load (lb/day)[3]	Average Nitrate-N + Nitrite-N Concentration (mg/L) [3]	Average Nitrate-N + Nitrite-N Load (lb/day)[3,4]
Arroyo Simi Upper	3.5	73	0.10	2	3.9	82
Arroyo Simi/Las Posas	6.6	641	0.6	60	7.1	693
Dry Calleguas	1.7	0	0.2	0	1.9	0
Arroyo Conejo Upper	1.7	37	0.05	1	1.8	38
Arroyo Conejo Lower[2]	5.3	514	0.7	70	5.0	487
Arroyo Santa Rosa	2.0	11	0.05	0	2.0	11
Conejo Creek Upper	8.6	648	1.1	85	9.5	715
Conejo Creek Lower	4.1	266	0.4	23	8.4	541
Calleguas Creek Upper	7.8	462	1.1	65	11.8	698
Calleguas Creek Lower	13.0	840	0.9	60	14.0	906
Revolon Slough and Ag Drains	49.5	1388	0.22	6	51.1	1435
Mugu Lagoon [5]	18.3	4879	1.0	372	19.5	5606

1 Non-detects were assumed to equal half the detection limit in the calculation of average concentrations.
2 Lower Arroyo Conejo concentrations summarize monitoring conducted before Hill Canyon began nitrifying and denitrifying its effluent. Current concentrations are likely to be higher.
3 Loads are presented for information and comparison purposes only. The loads were calculated based on the baseline flows presented in Table 1-5 and will vary based on the actual flows present in the reaches.
4 Nitrate-N + Nitrite-N concentrations and loads are based on data for which nitrate and nitrite were collected on the same date at the same location. For this reason, Nitrate+Nitrite does not equal the sum of the nitrate and nitrite column.
5 Loads for Mugu Lagoon represent the total loading from the watershed to the lagoon.

Allowable nitrate and nitrate + nitrite loadings are currently exceeded in Calleguas Creek, Revolon Slough, and Mugu Lagoon. Current nitrate loadings exceed maximum allowable loadings by 125 lb/day in Calleguas, and 1100 lb/ day in Revolon Slough. Nitrate + nitrite loadings exceed maximum allowable loadings by 200 lb/day and 1100 lb/day in Calleguas and Revolon, respectively. Nitrite loadings equal maximum allowable loadings in the Arroyo Conejo downstream of Hill Canyon and the Arroyo Simi/Arroyo Las Posas downstream of the Simi Valley WQCP and exceed maximum loadings by 20 lb/day in the Conejo Creek upstream of Camarillo and 15 lb/day in Calleguas Creek. Nitrate-N and nitrate-N+nitrite-N loadings to Mugu Lagoon from the watershed exceed the maximum allowable loadings by 183 lb/day and 910 lb/day, respectively. Consequently, oxidized nitrogen loading/concentration reduction requirements will vary throughout the watershed.

TMDL, Waste Load Allocations, and Load Allocations

WASTE LOAD ALLOCATIONS

Moorpark and Camrosa are the only POTWs that discharge to reaches of Calleguas Creek that are on the 303(d) list for oxidized nitrogen. All the other POTWs discharge upstream of a listed reach. When the 303(d) list was made, Camarillo was the only POTW in the watershed nitrifying its effluent. This nitrification did not result in a listing for the Conejo Creek downstream of its discharge because of dilution. When Hill Canyon began nitrifying its effluent, the concentrations of nitrate throughout the Conejo Creek system increased. Concentrations downstream of Camarillo in Conejo Creek may be currently exceeding the oxidized nitrogen targets. If Simi Valley nitrifies its effluent as part of their implementation the ammonia and/or algae TMDL, a similar impact is expected to occur. For this reason, waste load allocations (WLA) are set for all the POTWs in the watershed, even though they may not currently be contributing to an exceedance of the oxidized nitrogen targets.

In the calculation of WLAs for the POTWs, it was assumed that no dilution was available for the effluent. As a result, the effluent limits and wasteload allocations were set equal to the target. WLAs for the POTWs were only determined for nitrate+nitrite. Because the target for nitrate+nitrite is less than the sum of the nitrate and nitrite objectives, compliance with a WLA for nitrate+nitrite will result in compliance with the nitrate and nitrite targets. The following table summarizes the effluent limits for each of the POTWs in the watershed.

Table 3-14. Nitrate-N + Nitrite-N Effluent Limits and WLAs

POTW	Daily Effluent Limit (mg/L)	WLA (lb/day) [1]
Hill Canyon WWTP	10	10Q
Simi Valley WQCP	10	10Q
Moorpark WWTP	10	10Q
Camarillo WRP	10	10Q
Camrosa WWTP	10	10Q
Olsen Rd. WRP	10	10Q

1 WLA determined based on the target concentration times the discharge flow times the necessary conversion factors. Because concentration is the target for the TMDL, the WLA will vary with the flow discharged from the POTW.

NON-POINT SOURCE LOAD ALLOCATIONS

Revolon Slough is the portion of the watershed where current oxidized nitrogen concentrations and loads exceed the maximum allowable loads by the greatest amount. It is also a waterbody that is comprised solely of non-point sources. There are no longer any POTWs discharging to the slough. As a result, all the reductions in loading must come from non-point source load allocations. Non-point source load allocations are also necessary for sources to Calleguas Creek and Arroyo Las Posas.

Based on the concentrations and loads presented in Table 3-7, agriculture is the most significant source of oxidized nitrogen compounds in all of these reaches. Concentrations of oxidized nitrogen in urban and open space runoff are significantly below the target concentrations. Additionally, the combined loads from these areas are less than 9% of the non-point source loads to the watershed. As a result, non-point source load allocations are only determined for agricultural sources of oxidized nitrogen.

Because agricultural discharges represent 80% of the flow in Revolon Slough, these discharges must meet the target concentrations for nitrate, nitrite, and nitrate + nitrite in order for the slough to meet water quality standards. Any dilution provided by other sources of flow serves as the margin of safety for the slough and can not be used as dilution for the discharges.

In Calleguas Creek and the Arroyo Las Posas, dilution is currently available from POTW discharges. However, as the load from POTWs increases due to nitrification, this dilution will be reduced. Therefore, these agricultural discharges would need to meet the nitrate, nitrite, and nitrate + nitrite targets as well.

The median concentration in agricultural runoff monitored under the 205(j) grant and during the CCCS study is much lower than the observed concentration in Revolon Slough (32 mg/L vs. 48 mg/L). A review of the data collected revealed that there was a wide range of nitrate concentrations in the discharges from the various agricultural monitoring stations. Although most of the sample results were between 28 and 35 mg/L, four out of the nine stations monitored had at least one sample with a concentration over 60 mg/L. This indicates that there may be significant differences in nitrate concentrations between farms in Ventura County. Another possibility is that there a significant source of nitrate to Revolon Slough that has not been accounted for in this analysis.

These uncertainties and the significant load reduction required for agricultural sources (70-80%) indicate that it may not be feasible for agriculture to meet the targets in Revolon Slough and potentially other areas of the watershed. Therefore, additional mechanisms for meeting the targets may need to be investigated. The implementation plan provides some ideas for possible alternatives and the phasing of the TMDL will allow time to investigate options.

The load allocations for agriculture are set equal to the target of 10mg/L nitrate-N + nitrite-N times the discharge flow and conversion factors (Q) in all reaches of the watershed. The load allocation is assigned to agriculture as a source category and not to individual farmers or landowners.

Margin of Safety, Seasonal Variations, and Future Growth

MARGIN OF SAFETY

Wasteload and load allocations in the Calleguas Creek watershed were calculated assuming no dilution of the discharges was available. However, flow from groundwater, urban areas, and open space can be up to 20% of the baseline flow in the waterbody and serves to dilute the discharges from agricultural areas and POTWs. The concentrations and loadings in these flows are 20-30% of the maximum concentrations in the waterbody. Therefore, the margin of safety (MOS) is approximately 15% of the maximum concentration/load in the waterbody depending on the proportion of non-POTW and non-agricultural runoff in the reach.

Because the margin of safety is based on an assumption of the amount of flow in the watershed, the actual margin of safety will vary depending on the actual flow and concentrations found in the non-POTW discharges. The baseline flow outlined for this TMDL is the dry weather 30Q3 flow, or the average of the lowest flows occurring on 30 consecutive days during the dry season, with a return period of 3 years. This flow is equal to the 15-20th percentile mean daily flow in the watershed. This means that 80% of the time, the flow component of the margin of safety is greater than estimated above and 20% of the time it is lower. To quantify the flow component of the margin of safety during the 20% of the time that the flows are lower than the baseline, a number of flows representing percentiles below 20 were selected and the margin of safety under these flow regimes was calculated. The following table summarizes these values.

Table 3-15. Estimated Margins of Safety under Different Flow Conditions

Percentile	Approximate Flow Represents [1]	Estimated MOS[2]
0.1	1Q10	2%
1	1Q3 and 7Q10	12%
5	7Q3 (Revolon, Conejo)	15%
10	7Q3 (Arroyo Simi, Calleguas)	18%

1 The actual percentile for each flow varies by the reach. The percentile for the 7Q3 flow varies the most, from the 3rd percentile in Revolon to the 10th percentile in the Arroyo Simi. As a result, both the 5th and 10th percentile calculations were included for comparison.

2 MOS estimated based on the associated percentile flows at VCFCD gage 803, upstream of Simi Valley WQCP. No other gages are available upstream of POTW discharges to allow for analysis.

As these calculations demonstrate, during the lowest flows observed in the watershed, the MOS is close to zero. However, for approximately 99% of the time, the flow component of the MOS is at least 10%.

When quantifying the margin of safety in this way, the variability of the upstream concentration data and the amount of oxidized nitrogen contributed from conversion from other nitrogen compounds in the watershed also need to be taken into account. To assess the variability of the upstream concentration data, the actual receiving water concentrations from the reaches above Simi Valley WQCP and above the Hill Canyon WWTP were examined. The following table summarizes the 90th, 95th, 99th, and 99.9th percentile concentrations in these reaches and the associated concentration MOS. The overall MOS was developed by assuming that the 90th percentile concentration corresponds to the 10th percentile flow, the 95th percentile concentration corresponds to the 5th percentile flow, and so on.

Table 3-16. Estimated Margins of Safety under Different Flow Conditions

Percentile	Nitrate-N + Nitrite-N Concentration Arroyo Simi Upper (mg/L)	Nitrate-N + Nitrite-N Concentration Arroyo Conejo Upper (mg/L)	Estimated Concentration MOS [1]	Estimated Total MOS
99.9	5.78	8.8	12-42%	0.2-0.8%
99	5.67	6.7	33-43%	4-5%
95	5.23	4.1	48-59%	7-9%
90	4.93	3.3	51-67%	9-12%

1 The estimated MOS is calculated based on the maximum allowable concentration in the reach downstream of Simi Valley and Hill Canyon (10 mg/L-N).

Additional concentrations of oxidized nitrogen will be contributed by conversion of ammonia and organic nitrogen downstream of discharges. The concentrations contributed by this conversion were estimated based on the maximum allowable ammonia discharge and average ammonia discharge from the POTWs. Using assumed conversion rates and the travel time through the watershed, it is possible to estimate the concentration increase that may occur from conversion of the discharges of other nitrogen compounds. If this concentration is added to the upstream concentrations, estimates of the MOS considering the conversion of ammonia and organic nitrogen discharges can be determined. By estimating the increase in concentration in this manner, uptake of the other nitrogen compounds and losses to groundwater and surface water extractions are not taken into account. Additionally, the calculation assumes that the POTWs discharge the maximum allowable ammonia concentration at the same time as they are discharging the maximum allowable oxidized nitrogen concentration. Therefore, this represents a conservative assumption about the amount of conversion to oxidized nitrogen that could occur in the watershed due to other nitrogen compounds.

In the Conejo system, if the maximum ammonia discharge occurred with the existing organic nitrogen concentrations, approximately 6 mg/L of oxidized nitrogen would be added through oxidation of ammonia and organic nitrogen. Approximately 2 mg/L of oxidized nitrogen would be added under average discharge conditions. In the Arroyo Simi, approximately 5 mg/L of oxidized nitrogen would be added to the system under maximum discharge concentrations and 1.5 mg/L during average concentration discharges. Based on these estimates and under extreme worst case conditions (no flow from urban, groundwater, or open space areas and concentrations in discharges from all sources at the maximum allowable concentration), it is possible that the oxidized nitrogen TMDL could be exceeded in the Calleguas Creek system due to conversion of ammonia discharges to oxidized nitrogen. However, it is unlikely that the worst case conditions would all occur simultaneously and under expected discharge conditions, the estimated MOS will be at least 5% for all flow conditions greater than the 7Q10 flow.

The overall MOS for this watershed will vary depending on the upstream concentration, the amount of ammonia and organic nitrogen discharged from the POTWs, and the amount of flow in the watershed. Under worst case conditions, the MOS will be near zero. However, for at least 95% of the time, the MOS will be greater than 5% in all reaches of the watershed.

SEASONAL VARIATIONS

Should surface water in this watershed ever be used as a municipal drinking water supply, it is likely that sufficient water to provide this supply will only be available during storm events. For this reason, it is important to discuss the wet weather conditions for the oxidized nitrogen TMDL. Because the targets are expressed in terms of concentrations rather than loads, the increased loads due to storm flows will still meet the targets assuming that the concentrations do not exceed the targets. As shown in Table 3-17, wet weather concentrations of nitrite are equal to or lower than dry weather concentrations for all land uses, and nitrate concentrations in agricultural runoff are reduced by 50%. Wet weather concentrations of nitrate from urban and open space land uses increase from dry weather situations, but only to levels about one-tenth of the target. POTW concentrations do not change significantly during wet weather situations.

Table 3-17. Nitrate-N Concentrations and Loads from Surface Runoff

Land Use	Median Dry Total Nitrate-N Concentration (mg/L)	Median Wet Total Nitrate-N Concentration (mg/L)	Median Dry Total Nitrite-N Concentration (mg/L)	Median Wet Total Nitrite-N Concentration (mg/L)
Urban	0.29	1.4	0.1	0.026
Agriculture	32.3	20.8	0.19	0.081
Open Space	0.28	0.67	0.045	0.045

Monitoring data in Revolon Slough during storm events showed a significant reduction in nitrate concentrations from dry weather conditions. The maximum observed concentration in 5 storm events was 16.6 mg/L of nitrate-N. The mean and median concentrations (9.9 and 8.2 mg/L) did not exceed the nitrate target for the slough. Because current conditions demonstrate that oxidized nitrogen concentrations are significantly reduced during storm events, the implementation plan presented to meet dry weather targets should result in compliance with wet weather conditions.

FUTURE GROWTH

Over the past 30 years, rapid growth has been occurring in the Calleguas Creek watershed. Between 2000 and 2020, the population of Ventura County is expected to increase by 23% to 915,000 people (Ventura County Organization of Governments, 2000). This increase in population will likely increase the flows and loadings from the POTWs in the watershed. However, because the targets are concentrations and the WLAs are the target concentrations times the flows (and a conversion factor), the WLAs will accommodate future growth as long as the target concentrations are achieved (see Table 3-14).

Implementation Plan

An overall implementation plan for nutrients has been developed and is provided in Section 5 of this document. Implementation measures for the oxidized nitrogen TMDL are included as part of this overall implementation plan.

Section 4. Algae and Dissolved Oxygen TMDL

Introduction

This TMDL was originally developed to address the 1998 303(d) listings for algae in the Calleguas Creek Watershed. Because of the relationship between algae and dissolved oxygen, the TMDL evolved into addressing both listings. This TMDL has developed a preliminary target for algal biomass and developed an approach to meet the existing Basin Plan target for dissolved oxygen in order to address the impaired reaches listed in the 1998 303(d) list. Introductory material describing the regulatory context of TMDLs, a description of the watershed, the total nitrogen budget for the watershed, and flow and modeling information common to all the nutrient TMDLs is presented in Section 1 of this nutrient TMDL document. This section presents the TMDL for algae and dissolved oxygen but is closely tied to and must be considered in the context of the other nutrient TMDLs.

Pollutant Identification and Applicable Standards

303(D) LISTINGS

This TMDL addresses the 1998 303(d) listings for algae and dissolved oxygen/organic enrichment for the Calleguas Creek watershed. Algae is identified on the 1998 303(d) list as a pollutant/stressor in Revolon Slough, Beardsley Channel, and each of the four reaches of Conejo Creek (SWRCB, 1999). For each location, it is listed as a low priority. Low dissolved oxygen is identified on the 1998 303(d) list as a pollutant/stressor in each of the four reaches of Conejo Creek. For each location, it is listed as a medium priority.

BASIS FOR ALGAE LISTINGS

From 1991-1995, the Regional Board conducted surface water quality sampling in the Calleguas Creek watershed. During this sampling, field sheets were filled out by Regional Board staff to document such information as waterbody name, location, field conditions, stream width and depth, bottom substrate, water color, temperature, dominant land use, evidence of use, and what samples were taken. Sometimes the sampler noted an observation of algae, but often he/she did not. Not until late 1995 was the word algae found on the field sheet. That revised sheet had “algae growth” listed as a condition that could be circled, but it was not quantified. In September 1996 a field observation sheet provided for quantification of algae by percent ranges, but this was created after the listing process, and at which time observations by the Regional Board were apparently discontinued.

An Aesthetic Stressor Worksheet was developed by the Regional Board to summarize the visual observations made during 1991-1995 and used as the basis for the 303(d) listings (RWQCB, 1996b). The worksheet attempted to summarize the presence of factors such as trash, scum, algae, odor, color, etc. This assessment employed a subjective ranking system to describe the presence of algae (if any) which was observed and noted during the surface water quality sampling of the watershed. The ranking system scale ranged from 1-3 ("zero or slight", "moderate", "high"). If observations were not made, a "0" was supposed to be assigned. If a sampler wrote down an observation related to algae ("algae", "duckweed", "some algae", "lots of algae", etc.), the anecdotal comment was then assigned a value between 1 and 3 when the assessment summary was being developed. The number of observations per reach during 1991-1995 varies from zero to 13 (but only three reaches have five or more observations). Based on the number of observations and the number of criteria exceeded, a reach was then identified as "fully supporting (F)", "partially supporting (P)", or "not supporting (N)" beneficial uses. What constitutes "criteria exceeded" was not defined, but is assumed to be a value of either 2 or 3.

The Aesthetic Stressor Worksheet summary lists Revolon Slough, Conejo Creek Reach 1, and Arroyo Simi Reach 1 as "not supporting". It lists Beardsley Channel and Calleguas Creek Reach 3 as "partially supporting." The rest of the reaches are considered fully supporting or included no observations. In the *1996 Draft Water Quality Assessment Data Summaries* documentation (RWQCB, 1996a), the algae is described as contributing to a finding of:

- Not supporting both contact and non-contact recreation for Revolon Slough
- Not supporting both contact and non-contact recreation for the four Conejo Creek reaches (as a single category)
- Partially supporting both contact and non-contact recreation for Beardsley Channel

The 1996 Draft 303(d) list then listed algae as a cause of impairment for:

- Revolon Slough and Beardsley Channel/Wash
- Conejo Creek/Arroyo Conejo (confluence Calleguas to above Lynn Rd.)

And, finally, the 1998 303(d) list cites algae as a cause of impairment in:

- Beardsley Channel (above Central Ave.)
- Revolon Slough Main Branch (Mugu Lagoon to Central Ave.)
- Conejo Creek Reach 1 (confluence Calleguas to Santa Rosa Rd.)
- Conejo Creek Reach 2 (Santa Rosa Rd. to Thousand Oaks City Limit)
- Conejo Creek Reach 3 (Thousand Oaks City Limit to Lynn Rd.)
- Conejo Creek Reach 4 (above Lynn Rd.)

Summary of Algae and Related Listings

Table 4-1 presents a summary of the Aesthetic Stressor Worksheet Summary of 1991-1995 observations, the subsequent 1996 Draft Water Quality Assessment Data Summary, the 303(d) listings for 1996, and the 303(d) listings for 1998.

Table 4-1. Algae Data Listings in the Calleguas Creek Watershed (1995-1998)

Reach	Aesthetic Stressor Summary 1991-1995	1996 Draft Water Quality Assessment Data Summary	1996 Draft 303(d) List[2]	1998 303(d) List[2]
Arroyo Las Posas Reach 1	No observations	No	No	No
Arroyo Las Posas Reach 2	F 0/1			No
Arroyo Simi Reach 1	N 3/4	Algae: N for REC-1 and REC-2	No	No
Arroyo Simi Reach 2	F 1/1	No	No listings	No
Beardsley Channel	P 2/3	Algae: P for REC-1 and REC-2	Algae for REC-1 and REC-2	Yes
Revolon Slough	N 5/13	Algae: N for REC-1 and REC-2		Yes
Calleguas Creek Reach 1	No observations	No	No	No
Calleguas Creek Reach 2	No observations			No
Calleguas Creek Reach 3	P 2/5	No		No
Conejo Creek/Arroyo Conejo North Fork	F 1/2	No	No	No
Arroyo Santa Rosa Reach 1 and 2	No observations[1]	Unassessed	No listings	No listings
Conejo Creek Reach 1	N 5/5	Algae: N for REC-1 and REC-2	Algae for REC-1 and REC-2	Yes
Conejo Creek Reach 2	F 1/3			Yes
Conejo Creek Reach 3	F 0/2			Yes
Conejo Creek Reach 4	F 0/2[1]			Yes
Arroyo Conejo South Branch	No observations	Unassessed	No listings	No listings
Mugu Lagoon	No observations	No	No	No

F = Fully supporting
P = Partially supporting
N = Not supporting
#/# = exceedances/total number of observations

1 Observations summarized as Conejo Creek Reach 4 are believed to be Arroyo Santa Rosa data because no data were found in the log sheets for Conejo Creek Reach 4 and field logs were found for Arroyo Santa Rosa.

2 Reaches listed as "No" were not listed on the 303(d) list for algae, but the reach is listed for other constituents. "No listings" indicates that there were no 303(d) listings at all for the reach.

As indicated, no observations were made of Mugu Lagoon. As discussed in the oxidized nitrogen TMDL, nutrient effects in Mugu Lagoon are potentially of concern. Concerns have been raised over the algae and DO levels in the lagoon, however data are not available at this time to quantify the algae and DO levels in the lagoon, and the lagoon is not currently listed for algae or dissolved oxygen. Consequently, investigation of potential algae and dissolved oxygen concerns in the lagoon is highly recommended and will be conducted as part of the implementation plan.

Table 4-2 below summarizes the 1998 303(d) listings in the Calleguas Creek Watershed for the reaches impaired by algae and includes the related listings of nitrogen compounds and low dissolved oxygen in those reaches.

Table 4-2. 1998 303(d) Waterbodies Listed as Impaired Due To Algae

Waterbody	Source(s)	Priority	Miles Affected	Related Listings for Waterbody
Conejo Creek Reach 1	P; NP	Low	5.8	Ammonia & Organic enrichment/low DO
Conejo Creek Reach 2	P; NP	Low	2.67	Ammonia & Organic enrichment/low DO
Conejo Creek Reach 3	P; NP	Low	5.6	Ammonia & Organic enrichment/low DO
Conejo Creek Reach 4	P; NP	Low	4.98	Ammonia & Organic enrichment/low DO
Beardsley Channel (above Central)	NP	Low	6.16	Nitrogen
Revolon Slough (Central to Mugu Lagoon)	NP	Low	8.9	Nitrogen

NP= Nonpoint; P= Point

Observations by some POTWs in the watershed that were collected subsequent to the 303(d) listings have provided some additional information about algae levels in the listed reaches. In July 1996 both Camarillo and Hill Canyon began using the Regional Board's field observation form that allows for identification of algae type and quantification of algae based on percent cover ranges. The estimates of percent coverage were grouped as such: 0= none, 1= light (<5%), 2=moderate (5-25%), 3= high (25-50%), and 4= dense (>50%). The main algae type was also recorded, with 1= floating at surface, 2= floating in water column, 3= attached. Camarillo recorded percent coverage estimates of algae at a station upstream of the discharge and at a station downstream of the discharge, and Hill Canyon recorded percent coverage estimates of algae at two stations, both downstream of the plant discharge. Information from both plants almost always identified the algae type, when algae was present, as attached (periphyton). The average algae observations were 0.45 upstream and 0.43 downstream (n=100) for Camarillo and 2.0 (n=96) downstream of Hill Canyon. From these observations, it is clear that Camarillo has not documented an algae problem downstream of their plant. Hill Canyon has had some observations of high algae downstream of their plant, but on average it is classified as moderate (5-25%). Similar algae observations were not made in other areas of the watershed.

BASIS FOR DISSOLVED OXYGEN LISTINGS

The 303(d) listing for dissolved oxygen was based on water quality measurements primarily collected by the POTWs under their NPDES permits and the Thousand Oaks Characterization Study. 303(d) listings were made on the basis of 14 reaches throughout the watershed. Monitoring stations within each of the reaches were used to determine whether or not the beneficial uses in the reach were impaired by dissolved oxygen. If more than 40% of the samples collected at the monitoring stations in the reach were below the minimum objectives in the Basin Plan, the beneficial uses were considered to be impaired by low dissolved oxygen levels. Through these collection programs over 1000 samples were collected at a limited number of stations (11) throughout the watershed. The following table summarize the water quality samples used as a basis for the 303(d) listings.

Table 4-3. Water Quality Results Used as Basis for 303(d) Listing for Dissolved Oxygen [1]

Reach	Number of Stations	Number of Samples	Mean (mg/L)	Minimum (mg/L)	Percent below Objective	Reach Listed? [2]
Calleguas Creek R1 (Estuary to Broome Ranch Rd.)	1	3	8.3	5.7	0%	No
Calleguas Creek R2 (Broome Ranch Rd. to Portrero Rd.)		No data				No
Calleguas Creek R3 (Portrero to Lewis/Somis Rd.)	2	4	9.7	8.5	0%	No
Conejo Creek R1 (Confluence Calleguas to Santa Rosa Rd.)		No data				Yes
Conejo Creek R2 (Santa Rosa Rd. to T.O. City Limit)		No data				Yes
Conejo Creek R3 (T.O. City Limit to Lynn Rd.)	1	173	7.0	2.6	57%	Yes
Conejo Creek R4 (Above Lynn Rd.)		No data				Yes
Arroyo Santa Rosa Tributary	2	348	7.4	3.2	<1%	No listings
Arroyo Conejo North Fork	2	267	8.9	4.5	<1%	No
Arroyo Las Posas R1 and R2 (Lewis-Somis Rd. to Moorpark Fwy)		No data				No
Arroyo Simi R1 (Moorpark Fwy to Brea Canyon)	2	208	8.5	5.2	0%	No
Arroyo Simi R2 (Above Brea Canyon)		No data				No
Beardsley Wash/Channel		No data				No
Revolon Slough	1	1	N/A	7.0	0%	No
Duck Pond Ag Drain		No data				No
Mugu Lagoon		No data				No

1. Data obtained from the 1996 Water Quality Assessment Data Summaries (RWQCB, 1996a).
2. Reaches listed as "No" were not listed on the 303(d) list for ammonia, but the reach is listed for other constituents. "No listings" indicates that there were no 303(d) listings at all for the reach.

Table 4-4 summarizes the 1998 303(d) listings in the Calleguas Creek Watershed for the reaches impaired by dissolved oxygen/organic enrichment and the associated listings in those reaches.

Table 4-4. 1998 303(d) Waterbodies Listed as Impaired Due To Dissolved Oxygen

Waterbody	Source(s)	Priority	Miles Affected	Related Listings for Waterbody
Conejo Creek Reach 1	P; NP	Medium	5.8	Ammonia & Algae
Conejo Creek Reach 2	P; NP	Medium	2.67	Ammonia & Algae
Conejo Creek Reach 3	P; NP	Medium	5.6	Ammonia & Algae
Conejo Creek Reach 4	P; NP	Medium	4.98	Ammonia & Algae

NP= Nonpoint; P= Point

The monitoring conducted subsequent to the 1996 and 1998 303(d) listing by the POTWs during the CCCS and the Thousand Oaks Study confirmed the basis for the listing in Conejo Creek Reach 3. The listings for Conejo Creek R1, R2, and R4 (where no data were collected) resulted from all the reaches in the Conejo Creek system being combined into one listing in 1996 and then separated into different reaches in 1998.

WATER QUALITY OBJECTIVES

For algae, the Water Quality Control Plan for the Los Angeles Region (Basin Plan) contains a narrative objective for "biostimulatory substances". The Basin Plan states (RWQCB, 1994, p.3-8):

> "Biostimulatory substances include excess nutrients (nitrogen, phosphorus) and other compounds that stimulate aquatic growth. In addition to being aesthetically unpleasant (causing taste, odor, or color problems), this excessive growth can also cause other water quality problems. *Waters shall not contain biostimulatory substances in concentrations that promote aquatic growth to the extent that such growth causes nuisance or adversely affects beneficial uses*."

The Basin Plan contains numeric objectives for nitrogen compounds in order to protect the municipal water supply and the warm water aquatic life habitat beneficial uses. No numeric nitrogen objective exists to specifically prevent "nuisance" aquatic growth. No numeric objective exists for phosphorus.

Because there can be an association between algae presence and depression of in-stream dissolved oxygen (DO), these two issues were considered in conjunction for this TMDL. The Basin Plan objective for DO states (RWQCB, 1994, p.3-11):

> "Adequate dissolved oxygen levels are required to support aquatic life. Depression of dissolved oxygen can lead to anaerobic conditions resulting in odors or, in extreme cases, in fish kills. Dissolved oxygen requirements are dependent on the beneficial uses of the waterbody. *At a minimum (see specifics below), the mean annual dissolved oxygen concentration of all waters shall be greater than 7 mg/L, and no single determination shall be less than 5.0 mg/L, except when natural conditions cause lesser concentrations."*

The watershed is listed for the beneficial use of WARM aquatic life, and this is the most stringent specific condition mentioned in the water quality objective. This specific condition 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."*

Separate but related TMDLs for ammonia and oxidized nitrogen compounds for the Calleguas Creek Watershed are being developed simultaneously with this TMDL. Those TMDLs will address the specific nitrogen compound listings on the 303(d) list and discuss how to meet the numeric limits set forth in the Basin Plan related to protection of the municipal water supply and aquatic toxicity concerns. This TMDL will discuss any possible additional requirements needed for nitrogen compounds due to impacts from algae and dissolved oxygen.

ECOREGIONAL NUTRIENT CRITERIA

Summary of the Criteria Documents

The EPA's Assistant Administrator signed 17 ecoregional nutrient criteria documents on December 29, 2000, followed by a Notice of Availability published in the Federal Register on January 9, 2001. However, the documents were not posted on the EPA's website or available from EPA document services at that time. Copies of the document were not able to be obtained until during the public review period for this nutrient TMDL document. EPA has identified 14 ecoregions in the continental United States. In these 17 documents, EPA has published national nutrient criteria for eight ecoregions for lakes and reservoirs, eight ecoregions for rivers and streams, and one ecoregion for wetlands.

These documents present EPA's current recommended criteria for both causative (phosphorus and nitrogen) and response (chlorophyll a and turbidity) variables associated with the prevention and assessment of eutrophic conditions. EPA expects that States and Tribes will use these ecoregional nutrient criteria as a starting point to identify more precise numeric levels for nutrients needed to protect aquatic life and recreational or other uses on a site-specific or subregion-specific basis. States and Tribes retain the discretion to adopt water quality criteria based on other scientifically defensible approaches to developing regional or local nutrient criteria that differ from these recommendations. States and Tribes are also encouraged to develop criteria for additional parameters such as dissolved oxygen, algal biomass, and biological integrity indices.

The criteria are empirically derived to represent conditions of surface waters that are minimally impacted by human activities and protective of aquatic life and recreational uses. Ideally, EPA wanted to base these criteria on actual reference conditions. The criteria would have been based on the 75th percentile of reference condition data. However, EPA did not deem any of the data they received as reference. Consequently, they performed a statistical analysis of the entire body of non-reference data. The 25th percentile of each season (winter, spring, summer, fall) was calculated, then the median of these four values was calculated. Basically, this approach assumes that the lower 25th percentile of all data overlaps with the top 75th percentile of reference condition data, so therefore the 25th percentile data can be used to represent reference conditions.

These criteria, developed under section 304(a), are based solely on data and the judgment that reference conditions represent the conditions necessary to attain beneficial uses and do not reflect consideration of economic impacts or the technological feasibility of meeting any specific level of water quality in ambient water. EPA expects States and Tribes to develop a plan for developing and adopting nutrient criteria that are published in 2000 and 2001 into State or Tribal water quality standards within one year of publication of these recommendations and to adopt or revise numeric nutrient criteria into State and Tribal water quality standards by 2004 (EPA, 2000d).

Impact of the Ecoregional Nutrient Criteria on this TMDL

The nutrient criteria found in these documents were based on statistical analysis of a limited data set (data contained in EPA's STORET database), which did not include any data from the Calleguas Creek watershed. The Calleguas Creek watershed appears to be in Ecoregion III, subecoregion 6. A summary of the data used to develop the nutrient criteria and the criteria values are summarized below (EPA, 2000e, p.17).

Table 4-5. Reference Conditions for Rivers and Streams Ecoregion III, Subecoregion 6

Parameter	No. of Streams N++	Reported Values		25% based on all season data for the decade	Reference Streams**
		Min	Max	25%-all seasons	75%- all seasons
TKN (mg/L)	40	0.05	4.25	**0.363**	
NO_2 + NO_3 (mg/L)	17	0.25	8.275	**0.155**	
TN (mg/L)- calculated	NA	0.075	12.525	**0.518**	
TN (mg/L)- reported	10	0.223	9.95	**0.5**	
TP (ug/L)	23	2.5	3212.5	**30**	
Turbidity (NTU)	13^{w}	1	35.875	**1.9**	
Turbidity (FTU)	21	0.775	47.25	**2.65**	
Turbidity (JCU)	-	-	-	**-**	
Chlorophyll-a (ug/L)- F	0^{z}	-	-	**-**	
Chlorophyll-a (ug/L)- S	2^{z,w}	2.3915	2.3915	**2.3915**	
Chlorophyll-a (ug/L)- T	0^{z}	-	-	**-**	
Periphyton Chl-a (mg/m^2)	-	-	-	**-**	

** as determined by the Regional Technical Assistance Groups (RTAGs)
N++= largest value reported for a decade/season
TN calculated is based on the sum of TKN + NO_2 + NO_3
TN reported is actual TN value reported in the database for one sample.
F Chlorophyll a measured by Fluorometric method with acid correction.
S Chlorophyll a measured by Spectrophotometric method with acid correction.
T Chlorophyll a b c measured by Trichromatic method.
NA Not applicable
s,f,w A season other than summer greatly predominates the data set (s=spring, f=fall, w=winter).
z Less than three seasons were used to derive the median

For quick comparison purposes, the *average* concentrations in the various reaches measured during the Calleguas Creek Characterization Study ranged from 2.26-53.8 mg-N/L for Total Nitrogen (minimum value = 1.30 mg/L-N, maximum value = 96.73 mg/L-N) and from 71-1290 ug-P/L for Total Phosphorus (minimum value = 25 ug/L-P, maximum value = 3200 ug/L-P). The lowest averages are for stations upstream of treatment plants. The average total nitrogen concentrations observed in much of the Calleguas watershed are significantly higher than the observations that were used to develop the nutrient criteria for the ecoregion. Because the criteria are based on a statistical analysis of data that does not include data representative of local conditions, the applicability of the criteria to the Calleguas watershed is questionable.

Because of the lack of information about the limiting causal variables for algae growth in the Calleguas watershed, it is more prudent to set targets for the response variables than to prescribe nutrient levels for this watershed. The nutrient levels presented in the EPA criteria documents are based on a statistical analysis of limited water quality data and have not been demonstrated to be effective levels below which algae does not impact beneficial uses in the Calleguas watershed. In this watershed, there may be other and more effective (both practically and economically) methods to control algae, if necessary. These criteria are only recommendations, and in the criteria documents the EPA states explicitly that they encourage more site-specific objectives to be developed. The approach outlined in this document and associated implementation plan could be used to develop site-specific criteria for the Calleguas watershed.

Numeric Targets

The goal of the TMDL is to protect beneficial uses designated in the Basin Plan. As such, the targets of the TMDL are the values that will result in protection of the beneficial uses. The purpose of this section is therefore to identify numeric or measurable indicators that can be used to evaluate attainment of water quality standards for the listed waterbodies.

As described previously, the Basin Plan contains a numeric water quality objective for dissolved oxygen, but not for algae. There are currently no nutrient limits in place relating to protection against eutrophication. Consequently, there are no numeric standards upon which to base a TMDL for algae. So, for algae, the narrative standard must be interpreted to develop a quantifiable target value to measure attainment or maintenance of the water quality standards. The narrative standard states that biostimulatory substances should not be present in concentrations that promote growth *to the extent that such growth causes nuisance or adversely affects beneficial uses*. It should be noted that the mere presence of algae is not alone a basis for impairment; impairment exists only if the presence causes nuisance or is harmful to the beneficial uses designated in the Basin Plan. Some algae is healthy for an ecosystem as it is a part of the aquatic food chain (EPA, 1999b). Consequently, it is necessary to define what constitutes “nuisance” or to define the phrase “adversely affects beneficial uses”. The main impacts that algae could have in this watershed include unsightly algal mats and depressed DO levels.

BENEFICIAL USE IMPACTS

Plant growth (including algae) can have impacts on recreation/aesthetics, drinking water supply, industrial and agricultural operations, and aquatic life support uses. Recreational and aesthetic impacts can include reduced water clarity by sloughed material, interference with swimming and other recreation, fouling anglers' nets, floating mats, slippery beds that make wading dangerous, and impairment of aesthetic enjoyment. Plant growth can cause impacts to the water supply through blockage of intake screens and filters and taste and odor problems. It can also impact industrial and agricultural operations by blocking or clogging screens, filters, and drainage channels. Plant growth can also impact the aquatic life support use by contributing to low dissolved oxygen concentrations from the nighttime respiration of large populations of aquatic plants and algae or by the decay of plant matter (EPA, 1999b).

Beneficial uses that algae are most likely to affect in this watershed are aquatic life habitat (WARM) and recreational use (REC-1 and REC-2). The most likely negative effect on aquatic life would result from low dissolved oxygen levels, and the most likely negative effect on recreation would be aesthetic impairment (which is the "nuisance condition" discussed below).

"Nuisance" Conditions (Recreation Beneficial Use Impacts)

To be in violation of "nuisance" conditions, a nuisance situation must be defined and the field conditions must exceed that definition for some fraction of the year. Because neither the Basin Plan nor the background information on how algae came to be listed define a quantifiable "nuisance" level, a literature review was conducted to help determine "nuisance" algal conditions. This literature search revealed that certain threshold concentrations of algal biomass as milligrams chlorophyll-a per square meter (mg chl-a/m^2) are commonly considered to constitute "nuisance" conditions. EPA's *Nutrient Criteria Technical Guidance Manual for Rivers and Streams* (EPA, 2000b, p.102) states:

> "Criteria for levels of periphyton algal biomass that present a nuisance condition in streams and impact aesthetic use have been recommended by several investigators. There is surprising consistency in these values, with a maximum of about 150 mg/m^2 chl-a being a generally agreed upon criterion…. .....While the 150 mg/m^2 level cannot be supported as an absolute threshold above which adverse effects on water quality and benthic habitat readily occur, it nonetheless is a level below which an aesthetic quality use will probably not be appreciably degraded by filamentous mats or any other of the adverse effects attributed to dense mats of filamentous algae (e.g., objectionable taste and odors in water supplies and fish flesh, impediment of water movement, clogging of water intakes, restriction of intra-gravel water flow

and DO replenishment, DO/pH flux in the water column, or degradation of benthic habitat) (Welch 1992). Avoidance of these problems in many stream systems may be achieved with a maximum 150 mg/m^2 chl-a criterion."

Algae and the Oxygen Cycle in Aquatic Environments (Aquatic Life Beneficial Use Impacts)

Algae can affect the beneficial use of warm freshwater habitat, because as the amount of algae increases, so does the corresponding oxygen demand from respiration. When respiration demands exceed oxygen transfer rates across the water surface (reaeration), low levels of dissolved oxygen can result. Extreme oxygen depletion can stress aquatic life (EPA, 1999b).

In addition to plant respiration, several other oxygen sinks exist in natural waters. The oxygen demand associated with the oxidation of organic matter suspended within the water column is called carbonaceous biochemical oxygen demand (CBOD). The oxygen demand associated with the oxidation of ammonia and organic nitrogen to nitrate is called the nitrogenous biochemical oxygen demand (NBOD). Organic matter held in the bottom sediments also undergoes aerobic decomposition, demanding dissolved oxygen from the overlying water column. Each process is impacted by the in-stream water column temperature, with higher temperatures consistently resulting in lower predictions of in-stream dissolved oxygen (Warwick, 2000). See Figure 4-1 for a visual description of the oxygen cycle.

Insert Figure of Dissolved Oxygen Cycle

Figure 4-1. Conceptual Model of the Oxygen Cycle in Aquatic Environments

SELECTED NUMERIC TARGETS

Because of the described interrelationship between algae and dissolved oxygen, the two water quality targets for this TMDL to prevent aesthetic nuisance and adverse affects on beneficial uses due to algae are:

- A maximum of 150 mg/m^2 chlorophyll-a
- A minimum of 5.0 mg/L dissolved oxygen

The nuisance value for streams reported in the literature (150 mg/m^2 chlorophyll-a) should be reviewed and adjusted as necessary for site-specific conditions based on what value the local community deems acceptable. The targets listed above only apply to the reaches listed on the 1998 303(d) list for algae and dissolved oxygen. Mugu Lagoon has no data for algae and limited dissolved oxygen data, and is not listed on the 303(d) list for algae or dissolved oxygen. In addition, there is no similar scientific consensus on a "nuisance" algae threshold in a lagoon environment. For these reasons, no target is being set for Mugu, and no reduction of the current amount of algae biomass in Mugu Lagoon can be advocated without further monitoring and quantification of biomass. Although no algae target has been determined for the lagoon, nutrient loadings to the lagoon will be reduced by 30%-50% through implementation of the nutrient TMDLs presented in this document. Additionally, modeling and monitoring of the lagoon and an assessment of the nutrient impacts on the lagoon is critical and is discussed in the Implementation Plan. Similarly, the Arroyo Simi is not listed on the 303(d) list and has not been demonstrated to have beneficial use impacts due to algae or dissolved oxygen. As a result, no targets have been set for this tributary. The following table summarizes the reaches to which the targets apply.

Table 4-6. Preliminary Targets

Reach	Max Algal Biomass (mg-chla/m^2)[1]	Minimum Dissolved Oxygen (mg/L)
Arroyo Conejo Upper	150	5.0
Arroyo Conejo Lower	150	5.0
Conejo Creek Upper	150	5.0
Conejo Creek Lower	150	5.0
Revolon Slough	150	N/A
Beardsley Channel	150	N/A

1 This algal biomass target has been selected from literature and is not based on local consensus as to what constitutes nuisance conditions. This target can be adjusted based on further studies and public input. This biomass limit must also be exceeded some percentage of time for a reach to be considered non-supporting. . A statistical method based on the data distribution will be used to determine if the target has been violated.

Mechanisms for Achieving Numeric Targets

WATER QUALITY INDICATORS

Numerous biological response indicators exist for algae/eutrophic conditions, including chlorophyll-a, algal biomass, dissolved oxygen, water transparency, fish yield, and pH. Consequently, for example, acceptable dissolved oxygen levels could be one way to indicate an acceptable level of algae. For this TMDL, two biological response indicators, algal biomass and dissolved oxygen, were set as targets. However, algae and dissolved oxygen are not indicators that can be directly limited by control measures (unless physical removal of algae is the control measure) and translated into wasteload and load allocations. Consequently, one or more of the factors causing algae and depressed oxygen levels may need to be used as mechanisms to meet the selected targets. Some of these causal factors include nitrogen compounds, phosphorus compounds, carbon, oxygen, pH, trace nutrients, sunlight, stream flow, temperature, channel type, grazing, and substrate. Although causal factors are a mechanism for achieving water quality goals, the success of control of the causal factors is best measured by biological response indicators. For this reason, the TMDL targets were set for response variables rather than causal variables.

In order to develop mechanisms to achieve the targets, connections must be made between the causal factors and the selected biological response targets. It is not simple, however, to link the presence and amount of these factors, both individually and in combination with each other, to the amount of algae present or to depressions in oxygen levels, especially with the limited data in this watershed. Because of the absence of chlorophyll-a data, the limited and somewhat ambiguous percent coverage range data, and the fact that neither of these targets can be applied directly by point or nonpoint sources, more information was gathered to help evaluate the existing situation and develop mechanisms for achieving the targets. Some additional monitoring was conducted in conjunction with this TMDL to better assess the algae and dissolved oxygen situation in the watershed. Before discussing this monitoring, it is necessary to explain the factors that control algae growth.

ALGAE GROWTH FACTORS

Many factors combine to determine plant growth in a waterbody. The first of these is whether sufficient phosphorus and nitrogen exist to support plant growth. The absence or limitation of one of these nutrients generally will restrict plant growth. However, even if all necessary nutrients are available, plant production will not necessarily continue unchecked. Many natural factors, including light availability, temperature, flow levels, substrate (growing surface), grazing, and bedrock type and elevation, control the levels of macrophytes, periphyton, and phytoplankton in waters (EPA, 1999b).

The most likely method of controlling algae may initially appear to be reducing nutrients (nitrogen and phosphorus compounds). Nutrients, in the appropriate amounts, are essential to the health and continued function of natural ecosystems. Depending on specific characteristics of the receiving waterbodies, they can be present in excessive, limiting, or optimal amounts. Insufficient nutrients will result in less than optimal growth of primary producers (i.e. plants, including algae). Adequate primary productivity is essential to support all other trophic levels and a healthy, diverse, productive ecosystem (EPA, 1998). Excessive nutrient loading, however, can result in excessive growth of algae and associated water quality problems. When analyzing the option of reducing nutrient levels, it is beneficial to know whether nitrogen or phosphorus is limiting. At a nitrogen-to-phosphorus (N:P) ratio of about 10 (on a mass basis) or less, nitrogen is usually considered to be limiting (Goldman, 1994, p.152), if nutrients are the limiting factor. Conversely, an N:P ratio greater than 10 generally indicates that phosphorus is limiting. The EPA's *National Strategy for Development of Regional Nutrient Criteria* (EPA, 1998) states that the ratio ranges from 7.2 for marine systems to 11.75 for freshwater systems.

Nutrient data gathered during the CCCS monitoring for phosphorus and nitrogen levels in the receiving waters are summarized in Table 4-7 below.

Table 4-7. Phosphorus and Nitrogen Concentrations in Calleguas Creek Reaches

Reach	Average Ortho-Phosphate Concentration (mg-P/L) [1]	Average Total Phosphorus Concentration (mg-P/L) [1]	Average Total Nitrogen Concentration (mg-N/L) [1,2]
Upper Arroyo Simi	0.04	0.11	5.36
Arroyo Simi/Las Posas	0.43	1.12	15.84
Arroyo Santa Rosa	0.28	0.45	2.71
Arroyo Conejo Upper	0.049	0.071	2.26
Arroyo Conejo Lower	0.53	0.82	14.12
Conejo Creek Upper	0.48	0.82	14.33
Conejo Creek Lower	0.93	1.29	16.53
Revolon Slough/Ag Drains	0.27	0.45	53.8
Mugu Lagoon	0.34	0.69	22.97

1 Non-detects were assumed to equal half the detection limit in the calculation of average concentrations.
2 The related TMDLs for Ammonia and Oxidized Nitrogen provide more detail on the individual nitrogen compound concentrations in the watershed.

Initial N:P calculations based on the CCCS data indicate phosphorus would be limiting over nitrogen in most of the watershed, if nutrients were the limiting factor. Average receiving water N:P ratios (both the total and inorganic form ratios) calculated from the CCCS data were all greater than 10, except on the Arroyo Santa Rosa. In contrast to initial calculations, the recent dissolved oxygen and nutrient monitoring on the Arroyo Conejo/Conejo Creek indicate that nitrogen could be the limiting nutrient in that portion of the system (N:P ratios were about 4). This more recent monitoring was performed after the Hill Canyon WWTP began experimenting with nitrification and denitrification, which changed the ratio of nitrogen to phosphorus in the receiving waters. Not enough data are available regarding the current or proposed treatment situation to determine which nutrient will be limiting, if nutrients are the limiting factor.

It appears from the field work done during this TMDL development that nutrients may not be the limiting factor in much of the watershed. One likely possibility is that substrate is limiting. Periphyton, or attached algae, need a surface (substrate) for attachment and growth. Consequently, areas with cobbled bottom and placed rip rap would be expected (disregarding other factors such as shading, velocity, etc.) to have higher algae levels than areas with sandy, muddy bottom for a substrate. From the limited field work performed under the CCCS monitoring program and the percent coverage data collected by the POTWs, this appears to be the case in this watershed.

48-HOUR DO AND NUTRIENT MONITORING

During the course of preparing this TMDL, it was determined that some continuous dissolved oxygen monitoring, combined with nutrient monitoring, could be useful for a number of reasons. This information could be used to determine, at the time of monitoring, an estimate of algal growth, if there were any nutrient limitations, and whether there were any DO violations at these locations. Dr. John Warwick (Professor and Chair, Department of Environmental Engineering Sciences, University of Florida) provided the recommended framework for the monitoring and the subsequent data analysis.

Dissolved oxygen probes were installed in two locations along the Conejo Creek between the Hill Canyon WWTP and the Camarillo WRP in the first week of June, 2000. The “Upstream Conejo” site was on the Arroyo Conejo Lower and the “Downstream Conejo” site was on the Conejo Creek Upper. DO measurements were collected every 15 minutes over the duration of approximately 48 hours at each location. Surface water samples were collected at each site to be analyzed for ammonia, nitrite, nitrate, organic nitrogen, total phosphorus, and orthophosphate. Sample collection occurred at regularly spaced intervals over a 24-hour period. Sample collection at the downstream station occurred 5.5 hours after sample collection at the upstream station in an attempt to sample the same parcel of water at both locations, based on a distance of 5.9 miles and an estimated average stream velocity of 1.7 fps. For more detailed information on the monitoring, see the Monitoring Plan and Monitoring Update in Appendix 1.

In addition, DO monitoring (at fifteen minute intervals for a 24 hour period) was also conducted at one site each on Revolon Slough (at Etting Rd.) and on the Arroyo Simi (just downstream of Madera Rd.) during the beginning of June, 2000.

Results of Nitrogen and Phosphorus Sampling

Several nutrient grab samples were taken during the monitoring over a 24-hour period on June 5-6, 2000. These samples were then composited to give an average concentration from the sampled period. The results are summarized in Table 4-8. The ammonia samples were analyzed individually and as a composite (the composite results are reported here). These results were used to calculate a nitrification rate for the reach, average dissolved inorganic nitrogen (DIN) values, and dissolved inorganic phosphorus (DIP) values in order to analyze nutrient limitation. DIN equals the sum of the ammonia-nitrogen and nitrate-nitrogen. DIP is assumed to equal the ortho-phosphate concentration[2]. As indicated in Table 4-8, average dissolved inorganic nitrogen (DIN) for the reach was 6.92 mg-N/L and average dissolved inorganic phosphorus (DIP) for the reach was 1.63 mg-P/L.

Table 4-8. Results of Composited Grab Samples for Nitrogen and Phosphorus During DO Monitoring

Location	Ammonia-N (mg/L)	Nitrate-N (mg/L)	Organic N (mg/L)	Ortho-Phosphate-P (mg/L)	Organic Phosphorus (mg/L)
Upstream Conejo Creek	0.90	6.23	0.90	1.79	0.31
Downstream Conejo Creek	0.10 (half detection level)	6.62	0.80	1.47	0.13
Average	0.50	6.42	0.85	1.63	0.22

Results of DO Monitoring

Table 4-9 and Table 4-10 summarize the results of the continuous dissolved oxygen monitoring at the two sites on Conejo Creek and at the individual sites on Revolon Slough and the Arroyo Simi.

[2] Although other forms of dissolved inorganic phosphorus may be present, ortho-phosphates are the dominant species represented.

Table 4-9. Results of DO Monitoring on the Arroyo Conejo/Conejo Creek

Dissolved Oxygen Values	Upstream Conejo		Downstream Conejo	
	6/12/00	6/13/00	6/12/00	6/13/00
Maximum (mg/L)	11.47	10.49	9.96	10.27
Minimum (mg/L)	4.50	4.28	6.41	6.21
Difference (Max-Min) (mg/L)	6.97	6.21	3.55	4.06
Time of Minimum	21:30	21:30	23:45	23:30

Note: During the morning of 6/14 while DO was still being monitored, 3 results were logged on the Downstream site which formed a minimum spike and therefore did not correspond with the rest of the data which followed smooth diel curves. These three results were most likely the result of an object lodging temporarily on the probe and were considered erroneous data.

Table 4-10. Results of DO Monitoring on the Arroyo Simi and Revolon Slough

Dissolved Oxygen Values	Arroyo Simi 6/7/00-6/8/00	Revolon Slough 6/8/00-6/10/00
Maximum (mg/L)	11.97	28.38
Minimum (mg/L)	7.61	5.47
Difference (Max-Min) (mg/L)	4.36	22.91
Time of Minimum	20:45	0:45

Note: Arroyo Simi and Revolon Slough were monitored over a period of time that captured only one full diel cycle.

Data Analysis and Discussion of Results

The 48-hour sampling data were used to estimate algal biomass, determine nutrient limitations, and observe DO variability through a diel period. The calculations performed by Dr. Warwick performed are described in Appendix 2. An electronic copy of the analysis is available upon request.

Algal Biomass Estimates

The first task of the data analysis was to estimate the amount of algal biomass present in the reach monitored on Conejo Creek. From the available site-specific monitoring data and some factors estimated from literature, an average rate of periphyton oxygen production was calculated. Using this value, an estimate of periphyton biomass was calculated. The average estimated periphyton biomass level in the Conejo reach was found to be 76 mg chl a/m^2 or 12.9 g-AFDM/m^2. [3] This biomass level is below the aesthetics "nuisance value" found in the EPA literature (150 mg chla/m^2, equivalent to approximately 22.5 g-AFDM/m^2). The calculated value is equivalent to about 55% of the "nuisance value".

One location each on Revolon Slough and Arroyo Simi were monitored for DO on different dates. No nutrient data was collected in concert with this DO data. A more simplistic analysis was performed to estimate the rate of periphyton oxygen

[3] Chl-a is the abbreviation for chlorophyll-a. AFDM is the abbreviation for ash free dry mass.

production at each station. The average periphyton biomass levels were then estimated to be 15.8 g-AFDM/m^2 in Revolon Slough and 17.7 g-AFDM/m^2 in Arroyo Simi. Both of these levels are less than the "nuisance value".

Nutrient Limitation

The second objective of the data analysis was to describe the degree of periphyton growth limitation in the Conejo reach that occurred as a result of the local presence of nutrients. The difference between the observed in-stream concentrations and the half saturation concentrations for dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphorus (DIP) will approximate the degree of growth limitation (and are used to calculate associated nutrient limitation terms, as described in Appendix 2).

The half saturation concentration is the concentration of DIN or DIP at which the algae growth rate would be half the maximum growth rate. Generally, significant reduction in algal biomass will not occur until the in-stream concentrations get close to the half saturation concentration (Warwick, 2000). Because the average observed in-stream concentrations (DIN= 6.92 mg-N/L, DIP=1.63 mg-P/L) are much greater than the half saturation concentrations (0.025 mg-N/L for DIN, 0.005 mg-P/L for DIP), it appears that there is an ample amount of nutrients for algae to grow unchecked. Because the reach was not overwhelmed with algae (from visual observation during sampling and a calculation of algal biomass equal to about half the nuisance level), it can be concluded that factors other than the concentrations of available nutrients, such as the availability of substrate, are likely limiting algal growth in this reach. Caupp, et al. (1991 and 1997) found substrate a very important limitation factor for the growth of periphyton.

Because there has been no systematic quantification of algae (other than subjective percent coverage range estimates near Camarillo and Hill Canyon), there also has been no demonstrated, correlated pattern between numeric algae biomass levels and nutrient levels. In addition, it appears that nutrients may not be the factor limiting algae growth. It should be noted that the stream bed near Camarillo is very sandy and muddy, with little to no substrate, while the stream bed near Hill Canyon is very cobbly, providing significant substrate for algae. Consequently, at this time any attempt to regulate nutrients to control algae would be unfounded, experimental, and imprudent.

Dissolved Oxygen Violations

The third objective was to identify any violations of the 5 mg/L DO objective, expected to occur during the evening hours when DO levels would be lowest. Extensive dissolved oxygen data (15-minute intervals over approximately two-day periods) were collected at four locations: Upstream Conejo, Downstream Conejo, Upper Arroyo Simi, and Revolon Slough. The Upstream Conejo site was the only site which had minimum DO values below the established standard of 5.0 mg/L. Specifically, minimum DO values for Upstream Conejo were as low as 4.50 mg/L on 6/12/00 at 21:30 and 4.28 mg/L on 6/13/00 also at 21:30. It is important to note the minimum DO values at the Downstream Conejo site were as low as 6.41 mg/L on 6/12/00 at 23:45 and 6.21 mg/L on 6/13/00 at 23:30. These data clearly indicate that the stream is recovering in this reach (i.e. minimum DO is increasing between the upstream and downstream sites). This means that the oxygen coming into the water column (reaeration) is increasing in relation to the amount being used. This could result from one or a combination of factors including increased reaeration, less substrate for algae growth (meaning less algae and therefore less respiration demand), lower CBOD, and/or lower NBOD.

Another important aspect of the DO data is the reduction in difference between maximum and minimum values from the Upstream to the Downstream Conejo sites. The magnitude of this difference is an indication of the size of the photosynthetic community (a larger community results in a higher range) and the level of in-stream reaeration (higher in-stream reaereation results in a smaller range). The average DO difference in the reach was reduced (from 6.6 at the Upstream site to 3.8 at the Downstream site), which reinforces the idea of a recovering reach.

Low values of DO typically occur during nighttime hours when algal communities utilize DO for respiration and do not produce any oxygen because there is not light for photosynthesis. Additionally, algal communities do not assimilate as much ammonia at night (no cell growth), leaving more ammonia available for nitrification to nitrate, thereby creating an additional sink of DO. While the average ammonium concentration at the Upstream Conejo site was 0.90 mg-N/L, the data from the individual samples collected demonstrates a clear diel variation in ammonia concentration, with this behavior supporting the aforementioned discussion (higher ammonia concentrations at night and lower concentrations during the day).

Meeting the Maximum Algal Biomass Objective

The information used to develop the algae 303(d) listings did not provide any quantification of algal biomass, nor a threshold by which to measure nuisance. The percent coverage data from Camarillo and Hill Canyon provide some insight into the algae situation near each plant. Camarillo appears to have little or no algae, whereas Hill Canyon's observations indicate a range of algae levels, with an average ranking of 2.0 (5-25% coverage). There are several ways of interpreting this data from Hill Canyon, and with no clear relationship between this data and the chosen periphyton algae target of 150 mg/m^2. One way of analyzing this data is to say that the average ranking of 2.0 (5-25%) translates into an average coverage of 15%. A published correlation between various biomass amounts and percent coverage has not been found, however one document indicates a possible interpretation of 150 mg chl-a/m^2 as 30% coverage (Welch, 1988). This interpretation was used in an *Evaluation of Nutrient Standards for Malibu Creek and Malibu Lagoon* (CH2M HILL, 2000). If this relationship is used and a linear analysis applied, the average coverage of 15% downstream of Hill Canyon would translate into an equivalent algal biomass of 75 mg chl-a/m^2.

The special DO monitoring returned preliminary, snapshot results which indicate that algal biomass was lower at the points measured in the listed reaches than the nuisance threshold taken from literature, 150 mg/m^2 chl-a. Consequently, information available at this time does not substantiate the implementation of algal biomass reductions, especially given the uncertain nature regarding nutrient limitation discussed earlier. It does underscore, however, the need for a community consensus regarding an appropriate algae nuisance level, the relationship between algal biomass (as mg chl-a/m^2) and percent coverage, and more and better monitoring.

Meeting the Minimum DO Objective

The fourth and final task from the analysis of this monitoring involved determining the best way to ensure compliance with the dissolved oxygen objective. As discussed earlier, there are several factors involved in the aquatic dissolved oxygen system. Two main processes provide oxygen to the water column: photosynthesis and reaeration. All photosynthetic plants produce oxygen. Reaeration occurs when oxygen is transferred across the water surface from the atmosphere. There are several processes which demand dissolved oxygen from the water column. Aquatic plants, including algae, and organisms such as fish use oxygen during respiration. The oxygen demand associated with the oxidation of organic matter suspended within the water column is called carbonaceous biochemical oxygen demand (CBOD). The oxygen demand associated with the oxidation of ammonia and organic nitrogen to nitrate is called the nitrogenous biochemical oxygen demand (NBOD). Organic matter held in the bottom sediments also undergoes aerobic decomposition, demanding dissolved oxygen from the overlying water column. (See Figure 4-1 for a visual description of the oxygen cycle.)

Consequently, algal respiration is only one of the processes removing oxygen from the water column. Given that reducing the amount of algal biomass through limiting nutrients is very complicated and could require extremely low levels of nitrogen and/or phosphorus, and because the need to reduce biomass for aesthetic reasons has not been proven yet, attempting to meet dissolved oxygen levels by reducing algal biomass would similarly be difficult and imprudent at this time.

Through analyzing the data gathered on the Conejo reach, Dr. Warwick determined that the dissolved oxygen levels would be able to be met through controlling other factors associated with oxygen demand. He adjusted effluent characteristics from Hill Canyon in the spreadsheet model analysis until the minimum DO value in the receiving water was above the target (the DO standard of 5 mg/L), assuming certain conditions, including temperature and periphyton respiration, remained the same. Dr. Warwick's analysis (See Appendix 2) demonstrates that the minimum DO standard of 5.0 mg/L can be met by controlling the Total Kjeldahl Nitrogen (TKN) level in the WWTP effluent and does not require reducing the size of the periphyton community.

TKN is the sum of ammonia nitrogen and organic nitrogen and is the amount of nitrogenous matter available for NBOD oxidation, one of the processes which removes oxygen from the water column. The impact of any source or sink of dissolved oxygen varies both spatially and temporally. The impact is cumulative as you move down through the system. Consequently, it is very difficult to determine the relative impact of any one of the sources, such as NBOD oxidation, as the reasons for what happened in the DO cycle upstream of the location are unknown. At the point in the stream where the monitoring was conducted, at the time the minimum dissolved oxygen was recorded, Dr. Warwick's analysis estimates that 93% of the DO deficit was due to effect of the oxygen demand accumulated from upstream of the point, and approximately 4% was due to NBOD oxidation. Analyzing only the effects of the new loads at this location and point of time, Dr. Warwick estimates that NBOD oxidation was approximately 55% of the total oxygen demand.

The spreadsheet analysis shows that the minimum target DO value of 5.0 mg/L can be met with an effluent TKN concentration of 3.5 mg-N/L (assuming an effluent DO concentration of 8.7 mg/L). The value of 3.5 mg/L TKN is based on several assumptions, almost all of which lend a large margin of safety to the estimate. These assumptions are as follows:

1. 100% of the stream flow is WWTP effluent (i.e. no dilution).
2. 100% of organic-nitrogen (determined from TKN chemical oxidation analysis) is available for biological conversion to ammonia.
3. 100% of ammonia-nitrogen is oxidized through nitrification, assuming no uptake of ammonia for periphyton cell synthesis (4.57 mg-O_2/mg-N).
4. Hill Canyon effluent analysis shows BOD_5 to be less than 5.0 mg-O_2/L, while a value of 5.0 was used to compute the ultimate CBOD number (7.5 mg-O_2/L).
5. Hill Canyon effluent analysis shows average DO to be 9.5 mg/L, while the minimum recorded value of 8.7 mg/L (during 1999) was used in the computations.

Collectively these conservative assumptions amount to a 25-50% margin of safety for a WWTP TKN discharge concentration of 3.5 mg/L.

An attempt was made to refine the estimate of the acceptable effluent TKN concentration by removing some of the conservative assumptions indicated above. The original conservative assumptions are reiterated below, followed by a sentence (in italics) explaining the change made to more accurately estimate a reasonable upper limit for Hill Canyon WWTP TKN concentration.

1. 100% of the stream flow is WWTP effluent (i.e. no dilution). *NO CHANGE.*
2. 100% of Organic-nitrogen (determined from TKN chemical oxidation analysis) is available for biological conversion to ammonia. *Only 80% of TKN is assumed to be available for biological oxidation.*
3. 100% of Ammonia-nitrogen is oxidized through nitrification, assuming no uptake of ammonia for periphyton cell synthesis (4.57 mg-O_2/mg-N). *The amount of oxygen demanded by unit of ammonia reduction was decreased to 4.33 mg-O_2/mg-N to reflect some ammonia loss due to aquatic plant uptake (Haug and McCarty, 1972).*
4. Hill Canyon effluent analysis shows BOD_5 to be less than 5.0 mg-O_2/L, while a value of 5.0 was used to compute the ultimate CBOD number (7.5 mg-O_2/L). *The average Hill Canyon BOD_5 value of 3.1 mg-O_2/L (for May-December 1999) was used to compute the ultimate CBOD number (4.65 mg-O_2/L).*
5. Hill Canyon effluent analysis shows average DO to be 9.5 mg/L, while the minimum recorded value of 8.7 mg/L was used in the computations. *The average Hill Canyon DO value of 9.5 mg/L (for May-December 1999) was used.*

Based upon the analysis, the amount of biologically oxidizable TKN in the Hill Canyon WWTP discharge should be 4.0 mg-N/L. Assuming that only 80% of TKN is available for biological oxidation (Item 2), this yields an upper limit estimate for Hill Canyon WWTP effluent TKN concentration of 5.0 mg-N/L. The conservative assumption of no dilution (100% WWTP effluent) remains, but it is also recognized that nighttime stream temperatures may be a little higher later in the summer. Consequently, this upper TKN effluent concentration of 5.0 mg-N/L is considered a best current estimate of effluent quality needed to achieve the DO objective (with only dilution as a margin of safety).

This estimated TKN range of 3.5-5.0 mg-N/L should be considered preliminary. Additional monitoring is necessary to more accurately determine the in-stream TKN concentrations necessary to consistently achieve the 5.0 mg/L dissolved oxygen objective.

SELECTED MECHANISMS FOR ACHIEVING NUMERIC TARGETS

As discussed previously, the basis for the 303(d) listings for algae do not provide quantifiable biomass information that can be compared to the numeric target for algae. Additionally, estimates of algal biomass determined from the limited DO monitoring conducted on the Conejo, Revolon Slough, and Arroyo Simi were below the target nuisance value of 150 mg chl-a/m^2. Using a number of assumptions, percent coverage data from Hill Canyon and Camarillo was estimated to represent an algal biomass (approximately 75 mg chl-a/m^2) below the algal biomass target. Based on the limited biomass estimates available, the algal biomass target does not appear to be exceeded in the watershed at this time. Until a nuisance value has been agreed upon and there is an acceptable amount of biomass data to assess whether the target is being exceeded, there is no justification for biomass reduction related to aesthetics. Consequently, no control strategies are required at present and no limits are set for any of the causal factors for algal growth, such as phosphorus. However, the implementation plan includes monitoring of algal biomass to fill in the data gaps. Based on this data, control strategies could be necessary in the future.

There are, however, violations of the Basin Plan dissolved oxygen objective in the Conejo portion of the system which are due in part to algae biomass presence. That is the rationale for using 5.0 mg/L DO as the second target for this TMDL. Based on the information available during the DO monitoring, it appears that the DO violations can be eliminated by reducing TKN discharges to the receiving water.

TKN (Total Kjeldahl Nitrogen) is the sum of ammonia nitrogen and organic nitrogen. A reduction in TKN serves to reduce the amount of nitrogenous biochemical oxygen demand (NBOD), because it reduces the amount of organic nitrogen which can be converted into ammonia and reduces the amount of ammonia which can be oxidized to nitrate, processes which demand oxygen. Theoretical calculations based on a limited monitoring program indicate that a TKN range of 3.5- 5.0 mg/L in the receiving waters of the Conejo system will result in achievement of the DO target. However, the actual TKN level necessary to maintain DO levels above the target may be greater or less than indicated by these theoretical calculations. Because the data are very limited, the level with the greatest margin of safety, 3.5 mg/L TKN, will be selected as the preliminary value for achievement of the DO objective. Data collected during implementation will be utilized to determine the final TKN value. The implementation plan allows for modification of the preliminary value based on the recommended further monitoring.

A reduction in TKN is a logical approach to achieving the dissolved oxygen target, because it is connected to the need to reduce ammonia in the watershed due to aquatic toxicity concerns. The TKN approach allows flexibility in reducing ammonia and/or organic nitrogen, and it is possible that the dissolved oxygen target could be satisfied simply by meeting the ammonia targets discussed in the ammonia TMDL.

Source Identification

The DO target is the only target which requires load reductions at this time. Because only the Conejo system is listed for DO, and the target is proposed to be achieved through reduction of TKN levels, only sources of TKN into the Conejo system will be discussed.

POTWS

Only Hill Canyon, Camarillo, and Olsen Road wastewater treatment plants are potentially affected by this TMDL. These three POTWs discharge year round to the Arroyo Conejo, Conejo Creek, and Arroyo Santa Rosa, respectively.

In May 1999, the City of Thousand Oaks began experimenting with nitrification and denitrification at the Hill Canyon WWTP. They are still optimizing these treatment processes but continue to nitrify and denitrify all of their effluent. Camarillo currently nitrifies but does not denitrify its effluent. Table 4-11 characterizes the current TKN discharges from each of these POTWs. The average concentrations were calculated from the CCCS data (collected from July 1998 through June 1999). During this time Camarillo was nitrifying, and Hill Canyon started experimenting with nitrification and denitrification in May of 1999.

Table 4-11. Average TKN Concentrations and Loads from POTWs

POTW	Average TKN (mg/L)	Average Flow (cfs)	Average Load (lb/day)
Hill Canyon WWTP	23.0[1]	14	1733
Camarillo WRP	4.2	3.2	72
Olsen Road WRP	4.8	0.3	7.8

1 Generally before Hill Canyon started nitrifying. Recent results show much lower TKN concentrations.

While the CCCS data show a very high effluent TKN for Hill Canyon, data from May to December 1999 shows that average effluent TKN has decreased to 8.8 mg-N/L since nitrification has been initiated.

OTHER SOURCES

Other sources of TKN in the Conejo Creek watershed appear to be much less significant than the POTWs. Concentrations of TKN collected at stations upstream of the Conejo Creek POTWs averaged 0.8 mg/L, and both ammonia and organic nitrogen values were often less than the detection limit. Downstream of the POTWs, receiving water concentrations of TKN increase significantly in response to the large loads from the POTWs. Additionally, 205(j) monitoring of nonpoint sources in the watershed reported TKN concentrations at or below 1.0 mg/L for dry weather agricultural, urban, and open space discharges. As a result, POTWs are considered to be the only significant source of TKN in the watershed during the critical season of algae growth in the summer.

Although POTWs are the only significant source of TKN identified in the watershed, the other sources in the watershed were characterized. Identification of these sources and quantification of the loads from these sources were estimated based on the assumptions used to develop a simple mass load spreadsheet model to characterize nitrogen compounds in the watershed. Concentrations in runoff from each source and estimated flows were used to approximate loads from the other known sources in the watershed (See description of model and assumptions in Section 1).

Urban And Agricultural Runoff

Surface runoff loads were estimated based on three land use categories: urban, agriculture, and open space. For each land use category, median concentrations observed in dry weather runoff during the 205(j) monitoring were used as the basis for calculation of loads. Flow estimates were not consistently collected during the 205(j) monitoring, making it difficult to directly calculate non-point source loads based on this data alone. As a result, load estimates were made based on the flow estimations presented in the model. Table 4-12 summarizes the estimated concentrations, flows, and loads by land use for each reach.

Table 4-12. TKN Concentrations and Loads from Surface Runoff

Reach	Arroyo Conejo Upper	Arroyo Conejo Lower	Arroyo Santa Rosa	Conejo Creek Upper	Conejo Creek Lower
Urban Dry Weather					
Median TKN Concentration (mg/L-N)	0.95	0.95	0.95	0.95	0.95
Estimated Flow (cfs)	1.8	0.92	0.31	0.35	0.08
Estimated Load (lb/day) [1]	9.2	4.7	1.5	2.0	0.4
Agricultural Dry Weather					
Median TKN Concentration (mg/L-N)	1.0	1.0	1.0	1.0	1.0
Estimated Flow (cfs)	0	0.39	0.29	0.39	0.14
Estimated Load (lb/day)	0	2.1	1.6	2.2	0.5
Open Space Dry Weather					
Median TKN Concentration (mg/L-N)	0.81	0.81	0.81	0.81	0.81
Estimated Flow (cfs)	0.8	0.38	0.31	0.3	0.16
Estimated Load (lb/day) [1]	3.5	1.7	1.3	1.3	0.9

1 Loads for ammonia component estimated assuming non-detects equal half the detection limit.

Groundwater, Atmospheric Deposition, and Sediment

Groundwater

For the purposes of estimating loads, groundwater seepage was assumed to equal any flow entering the surface water from the ground. This includes groundwater from defined aquifers and water passing through the top layers of the soil from irrigation, etc. and then being transported into the surface water system. Groundwater seepage loads were estimated using estimated groundwater flows and concentrations observed in groundwater monitoring. In the Thousand Oaks area, groundwater quality was based on groundwater monitoring conducted during the CCCS study. Although these data were collected from groundwater basins adjacent to those that actually would be seeping into the creek system, they are the only available groundwater data in the Thousand Oaks area. The flow rates for the groundwater were estimated using pumping flow rates for the Arroyo Simi and assumptions described in Section 1 for the Arroyo Conejo. Because the groundwater discharges in Simi are pumped, a significant seasonal variation in discharges is not expected. In the Thousand Oaks area, the impact of the rainy season on the discharge rates and concentrations of groundwater could not be evaluated based on the existing data. Because of the relatively low concentrations of TKN in groundwater, seepage into the creek system contributes a relatively small amount of TKN to the watershed. Table 4-13 summarizes the dry weather groundwater seepage concentrations and loads for each reach.

Atmospheric Deposition

Atmospheric deposition as a source is defined as TKN (ammonia plus organic nitrogen) deposited directly to the creek surface. TKN deposited to the land area in the watershed is assumed to be accounted for by the loadings in runoff from the various land uses characterized above. Estimates of dry weather atmospheric loads of TKN to creek surface were based on deposition loads measured at a National Atmospheric Deposition Program monitoring site in Glendale. Deposition rates in kilogram per hectare per day were estimated for each season of the year based on samples collected at this site.

Ammonia data for Glendale were available, however there was no organic nitrogen data. Organic nitrogen deposition estimates were made using the data for nitrate from the Glendale site (NADP, 2000), as data from Chesapeake Bay studies indicated approximately equal contributions of organic nitrogen and nitrate deposition (EPA, 1997).

To estimate deposition during dry weather, the average deposition rate calculated from data collected from 1982 through 1999 during the summer season (June through August) were used. The average deposition rate (0.0088 kg/hectare/day) was then multiplied by the estimated surface area of the reach to determine the estimated loadings of TKN to the reach from atmospheric deposition. As shown in Table 4-13, these direct atmospheric loadings are insignificant compared to the other loads of TKN in the watershed.

Table 4-13. Groundwater and Atmospheric Deposition Loads for TKN (lb/day)

Reach	Arroyo Conejo Upper	Arroyo Conejo Lower	Arroyo Santa Rosa	Conejo Creek Upper	Conejo Creek Lower
Groundwater					
Median Total TKN Concentration (mg/L)	0.1	0.1	0.1	0	0
Estimated Flow (cfs)	1.5	0.96	0.9	0	0
Estimated Load (lb/day)	0.81	0.52	0.48	0	0
Atmospheric Deposition					
Deposition rate (kg/acre/day)	0.004	0.004	0.004	0.004	0.004
Area of reach (acre)	20.6	2.8	5.6	21.7	5.7
Estimated Load (lb/day) [1]	0.163	0.022	0.044	0.175	0.045

1 Loads estimated assuming non-detects equal half the detection limit.

Sediment

Sediment is created by the weathering of host rock and delivered to stream channels through various erosion processes, including sheetwash, gully and rill erosion, wind, landslides, and human excavation. In addition, sediments are often produced as a result of stream channel and bank erosion and channel disturbance (EPA, 1999a). The two main categories of sediment contributions of TKN include hillslope delivery and in-stream erosion. All hillslope delivery (movement of eroded material to the waterbody, minus upslope storage) should be accounted for in the contributions of urban, agricultural, and open space runoff. In-stream erosion would be more of an issue during high flow periods, because higher velocities would cause scour of the streambed. During the critical summer, low flow period that we are concerned with in this TMDL, in-stream erosion is minimal. Also, this watershed has many areas which have banks lined with concrete or concrete rip-rap. This serves to reduce, if not eliminate, any bank erosion in these areas. Consequently, sediment contribution has been considered negligible in this analysis.

Existing and Maximum Allowable Concentrations

ALLOWABLE RECEIVING WATER CONCENTRATIONS

A preliminary maximum allowable algal biomass concentration was determined to be 150 mg/m^2 chlorophyll-a based on a nuisance literature value. This algal biomass target has been selected from literature and is not based on local consensus as to what constitutes nuisance conditions. This target can be adjusted based on further studies and public input.

Table 4-14. Preliminary Maximum Allowable Algal Biomass Concentration

Reach	Max Algal Biomass (mg-chla/m^2)[1]
Arroyo Conejo Upper	150
Arroyo Conejo Lower	150
Conejo Creek Upper	150
Conejo Creek Lower	150
Revolon Slough	150
Beardsley Channel	150

1 This biomass limit must also be exceeded some percentage of time for a reach to be considered non-supporting. A statistical method based on the data distribution will be used to determine if the target has been violated.

The minimum allowable receiving water dissolved oxygen concentration is 5.0 mg/L. The selected TKN concentration necessary to achieve the DO target in the Conejo system, which includes a large margin of safety, is 3.5 mg-N/L TKN. As previously stated, this TKN concentration is based on calculations using limited data. Although these concentrations are based on the best available current information needed to result in achievement of the targets, the actual TKN concentration needed to achieve the dissolved oxygen target may be greater or less than this value.

At any given point in the reach, the maximum allowable pollutant load is equal to the allowable TKN concentration multiplied by the flow and a conversion factor. However, flows, infiltration rates, algal growth rates, and uses of the water all vary based on the season, time of day, temperature, and type of water year (drought vs. wet years). These variables affect the TKN concentration and load necessary to achieve the target. The estimated allowable TKN loads for each reach for current critical conditions were calculated using the lowest three year monthly flow multiplied by the estimated maximum allowable TKN concentration of 3.5 mg-N/L. The concentration and associated loads are summarized in Table 4-11.

Table 4-15. Preliminary TKN Target Concentrations and Loads for Current Critical Conditions

Reach	Max TKN Concentration (mg-N/L)	Max Load (lb/day)
Arroyo Conejo Upper	3.5	75
Arroyo Conejo Lower	3.5	339
Arroyo Santa Rosa	3.5	19
Conejo Creek Upper	3.5	264
Conejo Creek Lower	3.5	226

1 Loads are presented for information and comparison purposes only. The loads were calculated based on the baseline flows presented in Table 1-5 and will vary based on the actual flows present in the reaches.

CURRENT RECEIVING WATER CONCENTRATIONS

The Calleguas Creek watershed has no body of quantitative data for algal biomass or chlorophyll a. There is virtually no quantifiable data to determine compliance with the algae target, but the limited data gathered during the DO monitoring reported algae levels in the Conejo, Revolon Slough, and Arroyo Simi below the targeted nuisance value of 150 mg chl-a/m^2 commonly reported in the literature. Percent coverage range data indicate little to no algae downstream of Camarillo and some algae downstream of Hill Canyon (possibly an average of 15% coverage, with a possible translation to 75 mg chl-a/m^2). The available data do not indicate that the maximum allowable algal biomass targets are being exceeded in the watershed. Therefore, there is no basis for any load reductions (algae or nutrients) at this time.

Dissolved oxygen concentrations measured in the Calleguas Creek Watershed between 1990 and 1998 are presented in Table 4-16.

Table 4-16. Dissolved Oxygen Concentrations in Calleguas Creek Watershed (1990-1998)

Reach	Average Dissolved Oxygen Concentration (mg/L)	Maximum Observed Dissolved Oxygen Concentration (mg/L)	Minimum Observed Dissolved Oxygen Concentration (mg/L)	Percentage of Samples below 5.0 mg/L
Arroyo Simi Upper	9.4	15.9	6	0%
Arroyo Simi/Las Posas	7.2	17.3	3	4%
Dry Calleguas	8.9	8.9	8.9	0%
Arroyo Conejo Upper	9.8	12.9	6.4	0%
Arroyo Conejo Lower	7.1	10.9	2.6	5%
Arroyo Santa Rosa	7.5	11.5	3.2	1%
Conejo Creek Upper	6.8	9.6	2.7	7%
Conejo Creek Lower	7.3	8.4	5.3	0%
Calleguas Creek	7.2	12.5	3.9	5%
Revolon Slough/Ag Drains	12.1	30.7	4.4	4%
Mugu Lagoon	9.6	14.8	4.1	4%

Dissolved oxygen levels below 5 mg/L were observed in no more than 7% of the observations for any reach. The Conejo system is listed for dissolved oxygen violations, and consequently the TKN limits have been applied to those reaches.

Table 4-17 below summarizes the results of the CCCS data for TKN concentrations in the Conejo Creek reaches of the watershed.

Table 4-17. Current Average TKN Concentrations and Loads in Conejo Creek Reaches

Reach	Average TKN Concentration (mg/L)[1]	Average Load (lb/day)[3]
Arroyo Conejo Upper	0.80	17.2
Arroyo Conejo Lower	12.14[2]	1176
Arroyo Santa Rosa	0.67	3.6
Conejo Creek Upper	8.95[2]	674
Conejo Creek Lower	6.21[2]	401

1 Non-detects assumed to equal half the detection limit in the calculation of average concentrations.
2 Before Hill Canyon was nitrifying. Current concentrations are much lower.
3 Loads are presented for information and comparison purposes only. The loads were calculated based on the baseline flows presented in Table 1-5 and will vary based on the actual flows present in the reaches.

For the Arroyo Conejo Upper and the Arroyo Santa Rosa, the current TKN concentrations and loads do not exceed the target concentrations or the maximum allowable loads. Based on the average conditions during the CCCS monitoring, the concentrations exceeded the estimated maximum loading range by 837 lb/day in the Arroyo Conejo Lower, 411 lb/day in the Conejo Creek Upper, and 175 lb/day in the Conejo Creek Lower.

Historically, the Conejo Creek system greatly exceeded the estimated maximum allowable TKN loads, however, nitrification of Hill Canyon effluent has resulted in much lower concentrations of TKN. NPDES monitoring conducted by Hill Canyon in 1999 demonstrated an average TKN concentration of 5.6 mg-N/L just downstream of their treatment plant (Station W-19) and an average TKN of 4.2 mg-N/L farther downstream (Station W-18) for the eight months after they began nitrifying their effluent. These data indicate that they may have the ability to meet an in-stream concentration of 5.0 mg-N/L for TKN (the upper end of the projected range) without adding additional treatment, but may require further treatment to meet the selected 3.5 mg-N/L TKN concentration (the lower end of the range).

Also, since Hill Canyon has started nitrifying, receiving water concentrations of TKN in the upper and lower reaches of Conejo Creek have decreased. Data from Camarillo WRP for June 1999, December 1999, and February 2000 shows average receiving water concentrations of TKN in the Conejo Creek Upper of 1.6 mg-N/L and in the Conejo Creek Lower of 1.2 mg-N/L. This data indicates that dissolved oxygen levels may be adequate and therefore not require TKN reductions by Camarillo.

TMDL, Waste Load Allocations, and Load Allocations

WASTELOAD ALLOCATIONS

Because the estimated maximum allowable TKN concentrations and loads apply only to the Conejo system, only Hill Canyon, Camarillo, and Olsen Road wastewater treatment plants are potentially affected. These three POTWs discharge year round to the Arroyo Conejo, Conejo Creek, and Arroyo Santa Rosa, respectively. Because the current receiving water TKN loads in the Arroyo Santa Rosa are already below the estimated maximum allowable, and because Olsen Road is shutting down within the next five years (and diverting their influent to Hill Canyon), it will not be assigned a waste load allocation (WLA).

In the calculation of effluent limits for Hill Canyon, it was conservatively assumed that no dilution was available for the effluent. Because no dilution was assumed and because the in-stream concentrations are maximum concentrations, the estimated effluent limit for Hill Canyon is equal to the in-stream preliminary TKN concentration of 3.5 mg/L.

Currently, the average effluent discharge of 3.2 cfs from Camarillo is diluted with approximately 14 cfs of upstream flow during current critical conditions (lowest three year monthly flow), the majority of which is discharged from Hill Canyon. The Conejo Creek Diversion Project, when operational, will divert the majority of flow in Conejo Creek to agricultural uses in the Pleasant Valley area. The diversion will be approximately 7 miles downstream from the Hill Canyon WWTP. The water rights application allows the diversion of an amount equal to Hill Canyon's effluent minus 4 cfs for in-stream uses and channel losses. An additional amount of water equal to the flow contributed by use of imported water in the region (estimated at 4 cfs) may be diverted when at least 6 cfs of water will remain in the stream downstream of the diversion point (SWRCB, 1997). Using the critical condition flow and subtracting the maximum amount of effluent that can be removed under the water rights decision (10 cfs), only 2.6 cfs may remain in the Conejo just upstream of the Camarillo WRP.

Because Hill Canyon is also affected by these TKN limits, it is reasonable to base the estimated effluent limits for Camarillo on the quality of the 2.6 cfs water joining its effluent. The quality of this water is dependent primarily upon the TKN concentrations in Hill Canyon's discharge. Consequently, the estimated effluent limit for Camarillo will be based on Hill Canyon meeting a TKN limit of 3.5 mg/L.

After these effluent concentrations for Hill Canyon were inserted into the watershed model and 2.6 cfs of flow was assumed to be left upstream of Camarillo WRP, Camarillo's effluent limits were calculated based on the need to meet the in-stream target range of 3.5 mg/L. To meet an in-stream TKN concentration of 3.5 mg/L, the TKN effluent limit for Camarillo would need to be 4.4 mg-N/L. The effluent limits are summarized below in Table 4-18.

Table 4-18. TKN Effluent Limits and WLAs

POTW	TKN Max Effluent Limit (mg/L)	WLA (lb/day)[1]
Hill Canyon WWTP	3.5	3.5Q
Camarillo WRP	4.4	4.4Q
Olsen Road WRP[2]	N/A	N/A

1 WLA determined based on the target concentration times the discharge flow times the necessary conversion factors (Q). Because concentration is the target for the TMDL, the WLA will vary with the flow discharged from the POTW. In addition, as described in the implementation plan, this WLA is not to be implemented until after the Ammonia TMDL has been implemented and further monitoring has been conducted.

2 Olsen Rd. does not require an effluent limit because it will be shut down and its influent diverted to Hill Canyon for treatment.

NON-POINT SOURCE LOAD ALLOCATIONS

There are no demonstrated significant loads of TKN from non-point sources in the watershed (refer to Other Sources under Source Identification). At this time, no reductions in loadings for non-point sources are proposed. Should increases in non-point source concentrations be observed during future monitoring, load allocations for these sources may be required at that time.

Margin of Safety, Seasonal Variations, and Future Growth

MARGIN OF SAFETY

The margin of safety (MOS) associated with the in-stream preliminary TKN concentration of 3.5 mg/L is estimated to be between 25% and 50%, based on conservative assumptions used to calculate the TKN concentration needed to meet the dissolved oxygen target. However, prior to implementing TKN WLAs in POTW permits, additional monitoring will be performed to refine the TKN level necessary to meet the DO target. An appropriate MOS can be applied at that time.

SEASONAL VARIATIONS

Because the primary source of TKN is POTWs, the loading to the watershed is relatively constant throughout the year. Wet weather monitoring of urban runoff and agricultural areas indicates that wet weather runoff does contain higher concentrations than dry weather runoff (see Table 4-19), however the concentrations are still below the preliminary in-stream TKN target concentration of 3.5 mg/L. Increased flows during wet weather that do not contain TKN loads above the target will serve to dilute loads coming from POTWs. Also, the critical conditions for dissolved oxygen violations related to algae growth are during the warm dry summer months when algal respiration at night is highest. Therefore, the load allocations developed for dry weather conditions are sufficiently protective of wet weather conditions, and no seasonal load allocations need to be developed.

Table 4-19. Median Wet Weather TKN Concentrations

Land Use	Median Wet Weather TKN Concentration (mg/L)	Median Dry Weather TKN Concentration (mg/L)
Urban	2.1	0.95
Agriculture	2.5	1.0
Open Space	2.5	0.81

FUTURE GROWTH

Over the past 30 years, rapid growth has been occurring in the Calleguas Creek watershed. Between 2000 and 2020, the population of Ventura County is expected to increase by 23% to 915,000 people (Ventura County Organization of Governments, 2000). This increase in population will likely increase the flows and loadings from the POTWs in the watershed. However, because the targets are concentrations and the WLAs are the target concentrations times the flows (and a conversion factor), the WLAs will accommodate future growth as long as the target concentrations are achieved (see Table 4-18).

Implementation Plan

An implementation plan for nutrients has been developed and is provided in Section 5. Implementation measures for the algae/dissolved oxygen TMDL are included as part of this overall implementation plan.

Section 5. Implementation Plan

Introduction

This implementation plan is designed to address the TMDLs for ammonia, oxidized nitrogen, and algae/dissolved oxygen developed for the Calleguas Creek watershed. The effect of implementing this plan will be to address the 303(d) listings for ammonia, nitrate+nitrite, nitrogen, algae, and low dissolved oxygen/organic enrichment in various reaches of the Calleguas Creek system. A phased approach to implementation will be undertaken to address some of the uncertainties associated with these TMDLs and to allow coordination with the development of other TMDLs for the watershed[4] and the Calleguas Creek Watershed Management Plan.

CALLEGUAS CREEK WATERSHED MANAGEMENT PLAN

Since 1996, a stakeholder group within the Calleguas Creek watershed has been actively working towards the development of a Watershed Management Plan for Calleguas Creek. The purpose of the Watershed Management Plan is to develop a strategy to address a variety of needs in the watershed: flood control, erosion and sedimentation, water quality, water resources, and habitat. When developed, this plan should identify mechanisms for addressing the water quality issues within the watershed, including 303(d)-listed pollutants. As such, the plan will serve as the ultimate implementation plan for all of the TMDLs within the watershed. The development of the Watershed Management Plan is anticipated to be completed in March of 2004 and approved by the Regional Board in March of 2005, at the same time the Board approves the remaining TMDLs for the watershed. The implementation actions and schedules for the nutrient TMDLs are designed to coordinate with the schedule for development and approval of the Watershed Management Plan and the TMDLs for the other 303(d)-listed pollutants.

Implementation Actions

The three nutrient TMDLs being implemented through this plan are interconnected and implementation actions taken to control one pollutant impact the mechanisms through which the others are controlled. In addition, certain implementation actions

[4] TMDLs for twenty-five other constituents will be developed by 2012 according to the schedule outlined in a consent decree between the EPA and Santa Monica BayKeeper and Heal the Bay. However the Calleguas Creek Watershed Management Plan group has offered to assist the Regional Board with the development of these TMDLs so that they can be adopted by 2005.

at this time may not be appropriate in the context of the overall Watershed Management Plan. For example, if these TMDLs were to require immediate implementation of major capital improvements to remove nitrogen and then, several years later, the Watershed Management Plan and/or other TMDLs required that all discharges should be removed from the creek system or that riparian habitat improvements could be implemented rather than additional nitrogen reductions to achieve the algae/dissolved oxygen TMDL, the public investment in nitrogen removal facilities would have been wasted. For these reasons, the implementation of the three TMDLs will be phased, with the implementation of the ammonia TMDL being first, followed by the concurrent implementation of the oxidized nitrogen and algae/dissolved oxygen TMDLs. This will serve two purposes. First, it will allow time to monitor the creek system after implementation of the ammonia TMDL and determine with greater certainty what additional actions, if any, will be necessary to achieve the targets for the oxidized nitrogen and algae/dissolved oxygen TMDLs. At the same time, it will defer most major capital improvements until after the Watershed Management Plan has been approved by the Regional Board, thereby ensuring that any costly improvements are consistent with the overall management plan for the watershed.

The ammonia TMDL is to be implemented first because it is identified as a high priority on the section 303(d) list and has the least uncertainty associated with it. Oxidized nitrogen and dissolved oxygen are listed as medium priorities on the 303(d) list, and algae is listed as a low priority. As actions are implemented for the ammonia TMDL, oxidized nitrogen, dissolved oxygen, and possibly algae levels throughout the watershed will change. Because of the magnitude of this change is uncertain, implementation actions for oxidized nitrogen and algae/dissolved oxygen are proposed in the second phase.

In addition, the algae and dissolved oxygen situation in the watershed has not been completely characterized. Therefore, implementation of the algae/dissolved oxygen TMDL will involve extensive monitoring during the implementation phase of the ammonia TMDL. After the implementation of the ammonia TMDL has been completed and the monitoring results have been obtained, a determination will be made as to whether additional implementation measures are needed to meet the targets presented in the algae/dissolved oxygen TMDL.

WLA IMPLEMENTATION AND SCHEDULE

The WLAs for each POTW are listed in Table 5-1. These WLAs and appropriate compliance schedules will be included in permits based on the schedules provided in Table 5-2 and Table 5-3, subject to the following conditions:

- WLAs presented in Table 5-2 and Table 5-3 may be revised prior to the dates they are placed into permits. Any revisions to these WLAs are to be based on the collection of additional information as described in the "Monitoring Plan" and "Special Studies" sections and/or completion of the Watershed Management Plan.
- The ammonia WLAs are to be based on a WER of 1.0 unless a site-specific WER is developed in accordance with EPA procedures and approved by the Regional Board.
- The oxidized nitrogen and TKN WLAs will be placed in the permit findings in the first post-TMDL permits (in 2002), with a notation that these WLAs will be incorporated into permits as effluent limits the next time they are updated (in 2005), unless these TMDLs are first modified based on the result of the Monitoring Plan, the Special Studies and/or the Watershed Management Plan.

The implementation schedules presented in Table 5-2 and Table 5-3 are consistent with the requirements of EPA's TMDL regulations, as presented in the revisions to 40CFR 130. According to those regulations, States must, as expeditiously as practicable, revise NPDES permits to include effluent limits consistent with the WLAs in the TMDL. The EPA is required to object to permits (pursuant to provisions of 123.44(k)) that have not incorporated these effluent limits within one year after expiration of the permit term, or where the permit term expired prior to the establishment of the TMDL, within one year after the establishment of the TMDL.

The schedule presented in Table 5-2 allows time for development and Regional Board approval of a site-specific WER for ammonia, should POTWs choose to develop a WER.

Table 5-1. Nutrient Wasteload Allocations

POTW	Ammonia-N Daily Effluent Limit [1,3] (mg/L)	Ammonia-N Monthly Effluent [2,3] Limit (mg/L)	Nitrate-N+Nitrite-N Daily Effluent Limit (mg/L)	Estimated TKN Daily Effluent Limit (mg/L)
Hill Canyon WWTP	8.4 x WER x Q	3.1 x WER x Q	10 x Q	3.5 x Q
Simi Valley WQCP	8.4 x WER x Q	2.7 x WER x Q	10 x Q	
Moorpark WTTP	8.4 x WER x Q	2.7 x WER x Q	10 x Q	
Camarillo WRP	4.1 x WER x Q	3.5 x WER x Q	10 x Q	4.4 x Q
Camrosa WRP	2.7 x WER x Q	2.2 x WER x Q	10 x Q	

1 Acute limit calculated based on the 95th percentile pH and temperature for the reach.
2 Chronic limit calculated based on average pH and temperature for the reach.
3 WLA determined based on the target concentration times the discharge flow times the necessary conversion factors (Q). Because concentration is the target for the TMDL, the WLA will vary with the flow discharged from the POTW.

Table 5-2. Permitting Schedule for Ammonia TMDL [1]

Permit Number	POTW	Date Current Permit Expires	Date Ammonia WLAs Placed in Permits	Date for Achievement of Ammonia WLAs
CA0056294	Hill Canyon WWTP	2001	2002	2002
CA0055221	Simi Valley WQCP	2001	2002	2002
CA0053597	Moorpark WTTP	2001	2002	2002
CA0063274	Camarillo WRP	2003	2002	2002
CA0059501	Camrosa WRP	2004	2002	2002

1 Assumes Regional Board will adopt Nutrient TMDLs in March of 2002 and place ammonia WLAs in NPDES permits by June of 2002, in accordance with the compliance schedule allowed in the Basin Plan.

The schedule presented in Table 5-3 for the oxidized nitrogen and TKN WLAs allows time for completion of monitoring and special studies to verify or adjust the oxidized nitrogen and TKN targets prior to placing them into permits (in 2005). This schedule allows coordination with other TMDLs for the watershed and the Watershed Management Plan, both of which are to be approved by the Regional Board by March of 2005. The range of dates presented in the table for compliance with the oxidized nitrogen and TKN WLAs reflects the range of possible controls that may be required to comply with the WLAs, based on the final TMDL targets. If it is determined, based on the monitoring and special studies, that appropriate targets and associated WLAs may be achieved without additional treatment, then compliance will occur immediately. If, on the other hand, it is necessary to construct additional treatment controls in order to achieve the final WLAs, it could take an estimated additional seven years to achieve the WLAs. Based on past experience, this is the time reasonably required to plan (1.5 years), comply with CEQA (2 years), finance, design (1.5 years), and construct (2 years) major capital improvements. Seven years is a reasonable amount of time for this purpose, although, if major obstacles are encountered, it could take longer to achieve the WLAs. It should be recognized that when these TMDLs are adopted on or before March 2002 by the Regional Board members, a shorter schedule for compliance with the final WLAs may be adopted. The Board could adopt a shorter time schedule that would effectively require POTWs to initiate planning and design activities prior to finalizing the TMDL targets, so that delays will be minimized. While this may speed up achievement of WLAs if the currently proposed WLAs are deemed appropriate, it may result in a waste of public funds if the WLAs are revised or if the overall TMDL implementation plan developed in conjunction with the Watershed Management Plan proposes different options, such as reverse osmosis, wetlands development, or water reclamation, to address the oxidized nitrogen and algae/dissolved oxygen issues.

Table 5-3. Permitting Schedule for Oxidized Nitrogen and Algae/Dissolved Oxygen TMDLs[1]

Permit Number	POTW	Date Current Permit Expires	Date Oxidized Nitrogen and TKN WLAs Placed in Permits	Date for Achievement of Oxidized Nitrogen and TKN WLAs
CA0056294	Hill Canyon WWTP	2001	2005	2005-2012
CA0055221	Simi Valley WQCP	2001	2005	2005-2012
CA0053597	Moorpark WTTP	2001	2005	2005-2012
CA0063274	Camarillo WRP	2003	2005	2005-2012
CA0059501	Camrosa WRP	2004	2005	2005-2012

1 Assumes Nutrient TMDLs adopted in March of 2002, that the oxidized nitrogen and TKN targets are verified and/or adjusted to reflect new scientific information derived from the special studies in March of 2005, and that the WLAs are incorporated into the permits in October of 2005.

LOAD ALLOCATION IMPLEMENTATION AND SCHEDULE

The oxidized nitrogen TMDL is the only nutrient TMDL that provides load allocations for non-point sources. The load allocations call for significant reductions in nitrate concentrations discharged from agricultural areas. One strategy for meeting the load allocations would be through voluntary implementation of agricultural Best Management Practices (BMPs).

Water and fertilizer in Ventura County are significant costs to farmers. For this reason, practices for efficient use of both these commodities have been in place on most farms since the drought period in the late 1980's. Because most farmers have already implemented some of the BMPs used to control oxidized nitrogen compounds in runoff, the significant nitrate reductions still needed to achieve current oxidized nitrogen targets may be difficult to achieve. The BMPs described in this section appear to have the potential to result in significant reductions in oxidized nitrogen concentrations. However, because these BMPs have not been widely implemented, estimates of the reductions possible have not been quantified in the field. As a consequence, alternative measures and studies (to be developed under the Calleguas Creek Watershed Management Plan) may be required to address oxidized nitrogen compounds in agricultural areas and effectiveness monitoring and studies of BMPs may be needed.

For agriculture, two types of BMPs can be employed to reduce pollutant loadings to the receiving water: pollutant management BMPs and water management BMPs. Pollutant management BMPs reduce the concentration and load of pollutants in discharged agricultural water. Water management BMPs reduce the amount of water discharged from agricultural areas. Because the oxidized nitrogen target is a concentration rather than a load, only pollutant management BMPs are discussed as potential oxidized nitrogen concentration reduction mechanisms. As part of the overall program to address agricultural discharges, the water management BMPs will likely also be included, but they are not relevant to oxidized nitrogen compounds. The BMPs listed in Table 5-4 were developed as potential implementation measures for agricultural runoff. These

BMPs were determined to be applicable to the current conditions in the watershed, and many of them go beyond the BMPs that have already been widely implemented by local farmers.

Table 5-4. Agricultural BMPs for Oxidized Nitrogen Compounds

Best Management Practice	Units	Nutrient Mgt. Effectiveness (percent)	Water Mgt. Effectiveness (percent)	Pollution Control Effectiveness (percent)
Conservation Tillage (329)				
No Till	Acre	5-10	5-10	
Mulch Till	Acre	5-10	5-15	
Contour Farming (330)	Acre	5-10	5-10	0-5
Contour Orchard and	Acre	5-10	5-10	0-5
Other Fruit Area (331)				
Crop Residue Use (344)				
Chopping and Chopping Waste	Acre	5-10	5-10	
Mulching using min. Tillage	Acre	10-15	5-10	
Filter Strip (393)				
Filter Strip (10-20 ft wide)	Acre	5-10		2-10
Filter Strip (20-40 ft wide)	Acre	5-15		5-15
Filter Strip (40-60 ft wide)	Acre	10-25		10-25
Buffer Strip (20-30 ft wide)	Acre	10-20		10-20
Landscaping (20-30 ft wide)	Acre	5-15		5-15
Grassed Waterway (412)	Acre	5-10	80-85	5-15
Hillside Bench (192)	Acre	5-10	10-15	
Irrigation System: Sprinkler (442)	Acre	15-25	40-65	15-20
Irrigation System: Trickle (441)				
Microspray System	Acre	20-25	60-85	25-35
Drip Irrigation	Acre	30-35	70-85	25-35
Irrigation System				
Tailwater Recovery (447)	Ea	5-15	40-45	5-10
Irrigation Water Management (449)	Acre	20-35	45-60	15-35
Runoff Management system (570)				
Sediment Basin (350)	Each		5-70	5-15
Infiltration Trench	per foot		5-10	(5-10)
Filter Strips	Acre	5-15		5-15
Sediment Trap, Box Inlet	Each		0-2	0-5
Filter Trap	Acre	10-25		10-25

1 From: "Calleguas Creek Watershed Erosion and Sediment Control Plan for Mugu Lagoon", National Resources Conservation Service, May 1995.

Additional information about agricultural BMPs is available on a videotape developed by the Department of Food and Agriculture specifically for California farmers. This videotape, entitled *Best Management Practices for Nitrogen Fertilizer and Water Use in Irrigated Agriculture*, outlines seven BMPs and a number of guiding principles for implementation of each BMP to help control nitrate discharges from agricultural activities. Although no information is provided about the actual reductions that may be achieved through the implementation of these BMPs, the overall goal of the video is to provide a mechanism for farmers to only apply the amount of nitrogen and water that the plants need to grow. Effective implementation of the BMPs on the video, in combination with the BMPs listed in the table above should provide significant reductions in nitrate discharges from agricultural areas.

The Soil Conservation District also has an extensive list of 209 BMPs for agriculture. Descriptions of the BMPs and design specifications are presented in Section 4 of the California Field Technical Guide. This guide is available on the Soil Conservation District's website at www.ca.nrcs.usda.gov/rts/sec4.htm. These BMPs have been developed based on the different soil types in Ventura County. However, like the agricultural video, no information is available about removal efficiencies, but many promising options are presented to reduce oxidized nitrogen discharges. This source of agricultural BMP information is useful because it includes design specifications for BMPs that are not included in the other sources of BMP information.

Most of these BMPs are not specific to oxidized nitrogen and can be used to control a number of pollutants in agricultural runoff. For this reason, implementation of these or equivalent BMPs may be required as part of a general agricultural pollution prevention program to address all agricultural water quality issues in the watershed. This program may also include monitoring to determine compliance with the load allocations, and studies or monitoring to determine the effectiveness of the BMPs implemented. The pollution prevention program will be developed as part of the Calleguas Creek Watershed Management Plan in conjunction with agricultural interests. Pursuant to the State's Nonpoint Source Management Plan, implementation of BMPs initially will be voluntary, but may become mandatory if sufficient participation and environmental benefits are not demonstrated in the watershed.

In addition to the implementation of agricultural BMPs in the watershed, an investigation of oxidized nitrogen sources to Revolon Slough (and potentially Arroyo Las Posas where significant inputs of oxidized nitrogen to the system have been identified in monitoring data) will be conducted. As described in the oxidized nitrogen TMDL, the median concentrations of nitrate in agricultural runoff are significantly lower than the observed nitrate concentrations in Revolon Slough. This indicates that there is either an unknown source of oxidized nitrogen in the watershed or that some of the agricultural areas discharge significantly higher amounts of oxidized nitrogen on average than the agricultural areas monitored during the Calleguas Creek

Characterization Study (CCCS) and 205(j) monitoring. Identification of the sources of high concentrations of nitrate will allow focused efforts to control the largest sources of nitrate to Revolon Slough.

As shown in Table 5-4, most of the BMPs for which information is available on effectiveness, will result in a minimal (5-15%) reduction in oxidized nitrogen concentrations. Higher pollutant removal efficiencies may be achieved by implementing a particular BMP in conjunction with other BMPs. For example, according to these estimates, a drip irrigation system could be combined with a filter strip to potentially reduce oxidized nitrogen discharges by up to 50%. If all feasible combinations of BMPs were implemented and achieved maximum possible removal efficiencies, the BMPs listed above could potentially result in oxidized nitrogen reductions of up to 60%. However, because some of these BMPs are already in place and because of the general uncertainty regarding the effectiveness of BMPs, actual removal efficiencies are likely to be less than the maximum percentages presented in Table 5-4. Actual removal efficiencies are expected to be somewhere in the range of 5% to 60%.

In conjunction with the implementation of reasonable agricultural BMPs, an evaluation of the applicability of the oxidized nitrogen targets in Revolon Slough (and perhaps elsewhere) may be appropriate. These targets in Revolon Slough are based on its designation in the Basin Plan as a potential municipal drinking water supply, due to the requirements in the State Board's "Sources of Drinking Water" policy. This policy states that:

> "All surface and ground waters of the State are considered to be suitable, or potentially suitable, for municipal or domestic water supply and should be so designated by the Regional Boards with the exception of:
>
> 1. <u>Surface and ground waters where:</u>
>   a. The total dissolved solids (TDS) exceed 3,000 mg/L (5,000 µmhos/cm, electrical conductivity) and it is not reasonably expected by Regional Boards to supply a public water system, or
>   b. . . .
>   c. . . .
> 2. <u>Surface Waters where:</u>
>   a. . . .
>   b. The water is in systems designed or modified for the primary purpose of conveying or holding agricultural drainage waters, provided that the discharge from such systems is monitored to assure compliance with all relevant water quality objectives as required by the Regional Boards."

Based on exceptions 1a and 2b in the "Sources of Drinking Water Policy," it appears that Revolon Slough may not be required to be designated as a municipal water supply. Average TDS concentrations monitored in Revolon Slough during the

CCCS were 3300 mg/L. Additionally, this reach has been modified to serve as an agricultural drain, which indicates that the municipal water supply beneficial use is unlikely to ever become an actual beneficial use of the waterbody. Groundwater recharge is also not considered to be significant in Revolon Slough, though recharge occurs in some unlined portions of Beardsley Wash. Dedesignating Revolon Slough as a municipal water supply would not impact the groundwater recharge beneficial use designed to protect groundwater wells used as drinking water supplies in the Beardsley Wash area that may be impacted by the surface water. With respect to nutrients, aquatic life impacts due to algae growth is another beneficial use of concern in Revolon Slough. As demonstrated in the algae/dissolved oxygen TMDL, however, there is currently no evidence that algae levels in the slough exceed generally accepted criteria for aesthetic impairment or that dissolved oxygen levels in the slough fall below the Basin Plan objective. So, in Revolon Slough the current nutrient levels appear to be protecting this beneficial use. For these reasons, special studies (described later in this section) may be the most appropriate way to address the oxidized nitrogen issues in Revolon Slough.

Load allocation actions will be conducted over a sufficiently long period of time to allow coordination with special studies and implementation actions resulting from all the TMDLs in the watershed that will impact agriculture. The following table summarizes a proposed schedule for implementation of the agricultural load allocations for oxidized nitrogen.

Table 5-5. Load Allocation Implementation Schedule

Implementation Action	Date
Development of Agricultural Pollution Prevention Plan as part of the Calleguas Creek Watershed Management Plan	2005
Begin implementation of BMPs or other mechanisms to address oxidized nitrogen compounds	2006
Effective date of oxidized nitrogen target for Revolon Slough	2012

To estimate whether or not the load allocation implementation actions described above would be sufficient to meet the water quality objectives in the receiving waters, expected concentration reductions from the actions were entered into the model developed for nitrogen compounds. Because the model simplifies the processes in the watershed, there is some uncertainty associated with the model. However, it does accurately follow the concentration changes observed in the watershed during the various monitoring efforts. Therefore, it can be expected to give an approximate estimate of the concentrations resulting from the proposed implementation actions. The development of a more accurate and complete model for the watershed may be warranted as part of the Calleguas Creek Watershed Management Plan.

Oxidized nitrogen concentrations in Revolon Slough resulting from implementation of agricultural BMPs were estimated by assuming that the BMPs would reduce current nitrate and nitrite levels by 60%, the upper end of the range of possible removal efficiencies. Based on this optimistic estimate, the nitrate concentrations in Revolon Slough were not predicted to meet the 10 mg/L water quality objective for municipal drinking water supplies. As described above, the uncertainties about sources of oxidized nitrogen in Revolon Slough make it difficult to determine with sufficient accuracy what the actual impacts of implementing BMPs on Revolon Slough nitrate levels will be. These preliminary results indicate that alternative studies may be necessary to address oxidized nitrogen compounds in Revolon Slough as described in the "Special Studies" section of this plan.

ANALYSIS OF IMPACTS

In the introductory section of the nutrient TMDL document (Section 1), an analysis of the total nitrogen loading to the watershed was summarized. As a result of implementation of the three TMDLs presented in this document, concentrations of total inorganic nitrogen (ammonia, nitrate, and nitrite) will be reduced by 33%, over 1,000,000 lbs/year. The reductions in organic nitrogen will be less significant because the TKN WLAs can be achieved through a reduction in organic nitrogen or ammonia and only apply to one tributary in the watershed. As a result, it is not possible to estimate a reduction in organic nitrogen for the watershed. Therefore, the reduction in total nitrogen as a result of implementation of the nutrient TMDLs was assumed to be approximately equal to the reduction in total inorganic nitrogen. The following table summarizes the estimated loadings of total inorganic nitrogen in the watershed after implementation of the TMDLs.

Table 5-6. Average Annual Loads of Total Inorganic Nitrogen in the Calleguas Creek Watershed

Source	lb/yr (dry)	% of Total Dry Load	lb/yr (wet)	Total Annual Load	% of Total Load	% of Land Use
POTWs	1,171,555	81%	57,741	1,229,296	59%	N/A
Agriculture	190,858	13%	383,199	574,057	28%	26%
Urban Runoff	7,534	1%	122,996	130,530	6%	24%
Open Space	6,257	0.4%	71,890	78,147	4%	50%
Groundwater	60,336	4%	2,974	63,310	3%	N/A
Atmospheric Deposition	1,053	0.1%	(1)	1,053	0.1%	N/A
Total for Watershed	1,437,593	100%	635,826	2,076,393	100%	100%

1 Wet weather atmospheric deposition is assumed to be accounted for in runoff from the various land uses.

The annual total inorganic nitrogen loadings resulting from implementation of the TMDLs assumed that a WER of 2.9 was developed for the watershed to determine the ammonia target. If a WER is not developed in the watershed, or only developed for certain reaches, then the total inorganic nitrogen reduction would be closer to 1,400,000 lb/yr which is equal to a 50% reduction over current levels.

Costs and Benefits of Implementation

An analysis of the impacts of implementing these TMDLs with respect to costs, benefits, and other public interest factors specified in Water Code Section 13000[5], is presented in Appendix 3. A summary of this analysis is presented below.

The ammonia TMDL will impose capital costs for ammonia removal of approximately $6,000,000 for the Simi Valley WQCP. The other POTWs either currently meet the ammonia WLAs or are in the process of constructing facilities to meet the WLAs. Implementation of the ammonia TMDL will potentially result in benefits for aquatic life (due to reduced toxicity and possible increase in DO levels) and recreation (due to better fishing). The exact magnitude of the benefits, however, are uncertain because the ammonia TMDL target is based on national recommended criteria developed by EPA multiplied by a water effects ratio (WER) reflective of ammonia toxicity in Calleguas Creek waters. Unless and until a WER is developed, the extent of impairment due to current ammonia levels and therefore the benefits of reducing ammonia levels are not quantifiable.

The oxidized nitrogen TMDL, upon implementation, will impose capital and ongoing costs on POTWs and agriculture. Total present worth costs to POTWs for removal of nitrogen could range from $15 million to $35 million. The costs to agriculture to implement all reasonable BMPs to reduce oxidized nitrogen levels, could be in the hundreds of millions of dollars (over $7,000 per acre). Moreover, there is the potential for even greater costs to agriculture, as the available information indicates that BMPs alone may be insufficient to achieve the oxidized nitrogen TMDL target of 10 mg/L. The benefits associated with implementation of the oxidized nitrogen TMDL are questionable. The target for the oxidized nitrogen TMDL is based on protection of surface waters within the watershed for use as a municipal water supply. Yet, there does not appear to be any benefit to meeting drinking water standards in local creeks and sloughs. That is because, based on experience elsewhere in the State, it is unlikely that public health officials would ever approve the use of creek waters as a municipal drinking water supply, irrespective of the nitrate concentrations or the level of treatment provided for discharges to creek waters. There are potential secondary benefits of reducing oxidized nitrogen levels in local surface waters. It is possible that reducing oxidized nitrogen levels would reduce algae and improve dissolved oxygen levels to some extent, thereby resulting in aesthetic, recreational, and aquatic life benefits. However, it has not been established that nitrogen is the nutrient or factor limiting algae growth in the watershed, that current algae levels are causing aesthetic or recreational impairments, or that, except for Conejo Creek, dissolved oxygen is a problem. It is also possible that reducing oxidized nitrogen levels in surface waters will reduce nitrate and nitrite levels in local

---

[5] Water Code Section 13000 requires the State and Regional Boards to regulate so as to achieve the highest water quality which is reasonable, based on consideration of economics and other public interest factors.

groundwater, thereby enhancing the acceptability of their use as municipal water supplies. The connection between nitrate concentrations in surface water and nitrate concentrations in groundwater recharged by the surface water has been observed in some areas, but not quantified. In Beardsley Wash and the Arroyo Las Posas, a reduction in surface water nitrate levels may benefit the long term municipal use of the groundwater, but the magnitude of the potential water quality improvement has not been determined.

The costs associated with implementation of the algae/dissolved oxygen TMDL will depend on the final TKN concentration and whether additional treatment controls are necessary to achieve the WLAs based on that value. If implementation of the ammonia TMDL results in achievement of the algae/dissolved oxygen targets, no additional costs will be necessary. If additional reduction of TKN is required, total present worth costs for several POTWs, specifically Hill Canyon and Camarillo, could be in the vicinity of $23 million. As a result of implementing this TMDL, aquatic life benefits will be achieved in the Conejo Creek system to the extent that low dissolved oxygen levels are impacting aquatic life. Some recreational benefits may also be achieved by reductions in algae concentrations. However, the extent of this benefit is unclear because of a lack of information regarding baseline algae levels and their relationship to TKN and algae levels.

MONITORING AND EVALUATION PLAN

The plan designed to monitor and evaluate the implementation of these three TMDLs should serve to demonstrate compliance with the TMDLs, WLAs and LAs, and also define existing algae conditions and determine the receiving water conditions resulting from ammonia implementation measures. As described in the algae TMDL, the information currently available about algae levels in the watershed is insufficient to determine any sort of baseline algae condition. A comprehensive algae monitoring program is needed to define this baseline condition and assess whether the assumptions made in the development of the algae TMDL are accurate. Ammonia is the only one of the three TMDLs that is solely based on current information and does not rely on conditions resulting from implementation of the other TMDLs. Both the oxidized nitrogen and algae TMDLs are dependent on the water quality resulting from implementation of the ammonia TMDL. Assumptions were made in the development of both of these TMDLs as to the concentrations of oxidized nitrogen and TKN that will result from the ammonia TMDL implementation. Monitoring data will be used to define baseline conditions for the oxidized nitrogen and algae/dissolved oxygen TMDLs after implementation of the ammonia TMDL. Therefore, the monitoring plan is designed to provide background information on the changed conditions, verify the accuracy of assumptions that were made, and provide compliance monitoring data. Additional monitoring may be conducted in conjunction with special studies developed for the watershed and to determine the effectiveness of BMPs implemented by agriculture.

The primary mechanism for determining compliance with the TMDLs will be through monitoring associated with the NPDES discharge permits in the watershed. Receiving water monitoring for ammonia, nitrate, nitrite, and organic nitrogen will be conducted on a monthly basis at the stations outlined in the NPDES permits. Compliance monitoring on Revolon Slough and other areas not covered by NPDES permits will be conducted through the development of a Calleguas Creek Watershed Monitoring Program. Stakeholders in the Calleguas Creek Watershed Management Plan group will develop a monitoring plan and choose appropriate parties to conduct compliance monitoring in these reaches.

Algae and Dissolved Oxygen Plan

The algae/dissolved oxygen TMDL in its current form is intended to deal with algae and DO issues based on the current lack of data and the assumptions made to address the lack of data. Consequently, more data needs to be gathered in order to substantiate or disprove these assumptions. Monitoring will need to be conducted after the ammonia implementation actions have taken place in order to assess compliance with the dissolved oxygen target and assess the associated TKN limit. While no reduction in algal biomass is required in this TMDL (mainly due to a lack of data), an assessment of existing algae conditions needs to be conducted. This should only occur, however, in conjunction with the development of and agreement on what constitutes an impairment of beneficial use due to algae, as this is essential to the success of any possible future control of algae. In addition, information needs to be gathered on the interaction between algae and water quality in order to establish firm relationships between algal biomass, nuisance conditions, and parameters that could be used to control algae. The relationship between algal biomass and percent coverage should also be investigated during this monitoring. This information will help illuminate the connection between percent coverage observations made by treatment plants and actual biomass present. It will also help determine the appropriate mechanism for measuring algae over the long term. Consequently, a very comprehensive evaluation and monitoring program will be conducted throughout the Calleguas Creek watershed over a several year period. The recommended process for monitoring and evaluating the algae and dissolved oxygen situation includes the following activities:

- **Evaluation of and agreement upon a quantitative endpoint for assessing beneficial use impacts due to algae.** This will involve conducting field surveys with a group which is representative of local interests and developing consensus within that group. This group will perform an assessment of beneficial uses associated with algae and conduct an evaluation of the algae nuisance target identified from literature values to assess whether the target should be revised to address conditions and public perceptions specific to the Calleguas Creek watershed. A conclusive endpoint will improve decision-making and provide guidance needed to establish water quality objectives that directly affect the attainment of that endpoint (Schiff et al, 2000).
- **24 hour dissolved oxygen monitoring in order to assess compliance with the dissolved oxygen target.** This monitoring should be conducted after implementation of the ammonia TMDL in order to evaluate the new water quality situation. The monitoring should be conducted over two days at several points in the watershed. This monitoring should be conducted several times during the critical summer months.
- **Collection of detailed, spatially representative estimates of algal biomass by direct field measurement during the dissolved oxygen monitoring in order to begin to quantify the algae conditions in the watershed.** This should involve measurement of algae both as mg chl-a per square meter and as percent coverage. To the extent possible, the same monitoring crew should be used to provide consistent percent coverage estimates. Additionally, a field guide to assist in the determination of percent coverage will be developed.
- **Collection of ammonia, nitrate, nitrite, organic nitrogen, ortho-phosphate, phosphorus, and BOD samples during the dissolved oxygen and algae monitoring.** Establishing the correlation between water column concentrations and algal biomass in this watershed are essential to the success of any future control strategies.
- **Evaluate whether the DO target is met after implementation of ammonia reductions. If the DO target is not met, implement TKN reductions.** If determined necessary to meet the DO target, Hill Canyon and/or Camarillo shall begin to implement TKN reductions. Through the implementation of TKN reductions, the appropriate TKN level necessary to meet DO levels will be determined.
- **After ammonia, oxidized nitrogen, and any necessary TKN controls have been put into place, determine compliance with the algae target.** Conduct a survey of the watershed when the system has come to equilibrium after the other nitrogen controls.

- **For those areas that exceed the algae targets, investigate all possible implementation actions to reduce algae to the target level.** This will involve the determination of the limiting causal factors for algae growth and an assessment through cost/benefit and effectiveness analysis of the possible methods of reducing algae (i.e. control of nutrients, substrate, channel morphology, sunlight, temperature, etc.).
- **Implement the selected algae reduction method(s).** After appropriate algae reduction measures have been selected, funding will be obtained and the selected measures will be put into place to achieve the algae target for the reach.

Mugu Lagoon

This monitoring program should occur across the watershed, with special attention also paid to Mugu Lagoon. The lagoon has its own unique physical and biochemical dynamics which need to be defined in order to address any problems which may exist there. Special issues related to the lagoon include the role that the influx and outflux of nutrients in the water column and sediments play in relation to algae levels in the lagoon and whether algae presents a nuisance in a lagoon which is not accessible to the public. In addition, the algae target identified in this TMDL is an appropriate starting place for river and stream environments, but not for a coastal lagoon environment such as Mugu Lagoon. If the local watershed group determines that algae is a problem in the lagoon, an appropriate target will have to be developed for that environment. The dissolved oxygen situation in the lagoon should also be more closely analyzed, and a DO target applicable to the lagoon's environment should be investigated. EPA has recently published ambient water quality criteria for dissolved oxygen in saltwater that protect coastal and estuarine animals in the Virginian Province (Cape Cod, MA to Cape Hatteras, NC). This criteria may be useful in investigating an applicable target for Mugu Lagoon. It is highly recommended that a special model be developed for the lagoon to define its unique hydrodynamic and water quality characteristics.

SPECIAL STUDIES

The targets presented in the three nutrient TMDLs were based on the best available information on levels that are required to protect the designated beneficial uses in the Calleguas Creek watershed. However, there are indications (as described in the TMDLs) that these targets may be too stringent for the site-specific conditions present in Calleguas Creek. This uncertainty surrounding the specific impacts of nitrogen compounds in the Calleguas Creek watershed indicates that special studies may be warranted prior to the implementation of the actions described above. The following list summarizes studies that are the most likely to produce information that could impact the TMDL targets. It should not be considered to be a comprehensive list of studies that could be conducted.

- Development of a water effects ratio (site-specific objective) for ammonia based on hardness and ionic concentrations in the Calleguas Creek watershed.
- Expanding on existing information to quantify the contribution of surface water loads of nitrogen to groundwater and the impacts of these loads on the groundwater recharge beneficial use.
- Assessment of the municipal water supply beneficial use designation for the watershed and potential de-designation of this use.
- Evaluating oxidized nitrogen loadings from different agricultural activities specific to the Calleguas watershed and investigating additional oxidized nitrogen loadings to Revolon Slough.
- Monitoring and assessment of "nuisance" algae conditions.
- Special assessment and monitoring of the unique physical and biochemical dynamics of Mugu Lagoon.

Conducting the above studies could result in the need to reevaluate the TMDLs and/or the basis of the 303(d) listings. Decisions to conduct these studies must be made in coordination with the Regional Board. These studies must be designed and conducted within the implementation schedule presented here. Therefore, if study workplans have not been developed, approved, and data collection and analysis completed before the scheduled permit incorporation or compliance dates, the wasteload and load allocations in these TMDLs will go into effect as scheduled.

ACTIONS REQUIRED OF OTHER ENTITIES

In addition to actions by POTWs and agricultural discharges, implementation of these TMDLs requires actions by others, including the Regional Water Quality Control Board and the Calleguas Creek Watershed Management Plan group. The implementation actions required of these entities are described below.

The Regional Board should adopt these or alternative nutrient TMDLs on or before March 2002, in accordance with the schedule set forth in the consent decree. In conjunction with adoption of the nutrient TMDLs, the Regional Board should amend the ammonia water quality objectives in the Basin Plan to reflect the latest scientific information and the requirements of Water Code Section 13241 and CEQA. Specifically, the Regional Board should adopt ammonia objectives equal to the EPA 1999 Update of Ammonia Criteria times a water effects ratio (WER), with the provision that if a site-specific WER has not been established for a given reach, a default WER of 1.0 will be utilized. At the same time it is amending the Basin Plan to adopt the nutrient TMDLs and new ammonia objectives, the Regional Board should reconsider the appropriateness of the MUN designation for creeks within the Calleguas Creek watershed, including but not necessarily limited to Revolon Slough and Beardsley Channel. The Regional Board should also amend the Basin Plan, consistent with these TMDLs, to require compliance with the nitrite and nitrate and dissolved oxygen objectives by 2012.

On or before March 2005, the Regional Board should adopt TMDLs for all other 303(d)-listed pollutants for the Calleguas Creek watershed and approve the Calleguas Creek Watershed Management Plan. At the same time, if appropriate based on any special studies conducted pursuant to this implementation plan and/or the results of the Calleguas Creek Watershed Management Plan, the Regional Board should revise the nutrient TMDLs.

The Calleguas Creek Watershed Management Plan should complete and submit to the Regional Board, on or before March 2004, the recommended TMDLs for the other 303(d)-listed pollutants and the recommended watershed management plan for implementing all TMDLs and addressing other water quality and water resources issues in the watershed. Upon Regional Board adoption of the remaining TMDLs and approval of the watershed management plan, the Calleguas Creek Watershed Management Plan should formally adopt and then initiate implementation of the plan. This is anticipated to occur on or soon after March 2005.

COORDINATED SCHEDULE FOR IMPLEMENTATION ACTIONS

The overall schedule for implementation actions required under these TMDLs is presented in Figure 5-1. This figure shows the interrelationship between the various actions necessary to result in an overall coordinated program to implement not only the nutrient TMDLs, but other TMDLs in the watershed. The schedule is constrained by the consent decree which requires the Regional Board to adopt these nutrient TMDLs by March of 2002 and many of the remaining TMDLs by March of 2005. The Calleguas Creek Watershed Management Plan group is planning to develop draft TMDLs for the other remaining pollutants on the section 303(d) list, as well as an overall, coordinated implementation plan for all TMDLs (under the Watershed Management Plan) by March of 2004. It is assumed that the Regional Board will adopt the remainder of the TMDLs and approve the coordinated implementation plan by March of 2005. This schedule requires that special studies start immediately upon completion of the draft TMDLs and be completed no later than March of 2003. This will allow the results of the special studies to be considered in the development of the overall implementation plan and will allow adjustment of the oxidized nitrogen and TKN targets, if appropriate, prior to Regional Board placement of the oxidized nitrogen and TKN WLAs into NPDES permits. To the extent the special studies are not completed in sufficient time for this purpose, the oxidized nitrogen and TKN targets and WLAs presented in these TMDLs will serve as default limits for the NPDES permits adopted in 2005, after approval of the Calleguas Creek Watershed Management Plan.

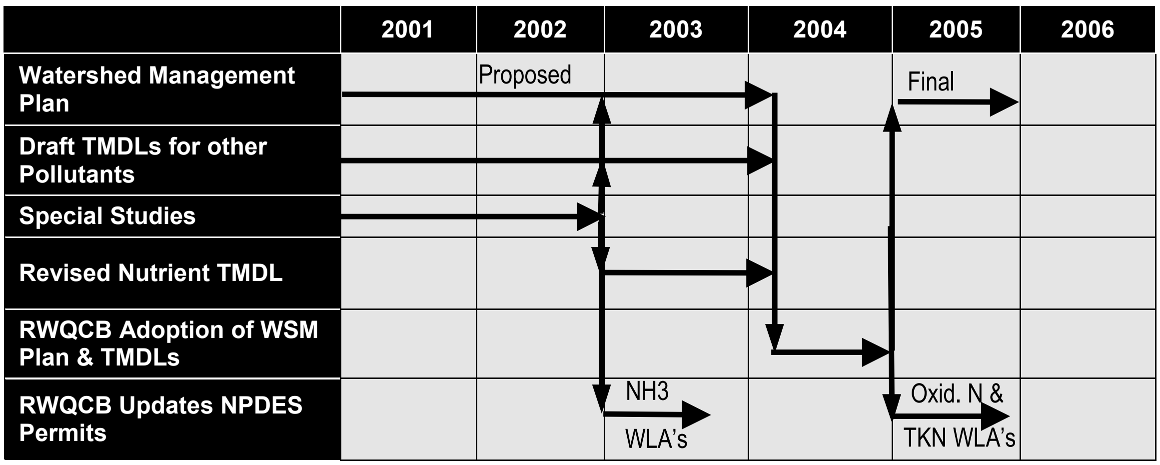

Figure 5-1. Coordinated Schedule for Implementation Actions

Schedule for Attainment of Water Quality Standards

Because POTWs are the major source of ammonia in the watershed, water quality standards will be met for ammonia when POTWs implement ammonia removal processes. Based on the schedule presented in Table 5-1, attainment of water quality standards for ammonia will be achieved by no later than 2002. (Occasional discharges from Camrosa and Moorpark are not expected to cause exceedances of water quality standards prior to implementation of ammonia limits in their permits.) Dissolved oxygen standards in Conejo Creek may be achieved on this same timeframe (with implementation of nitrification) or could take until 2012 if major, additional capital improvements are required.

For oxidized nitrogen, water quality standards in the Arroyo Simi and Conejo Creeks are currently being attained, but may not be attained after ammonia implementation measures. If, as a result of nitrification, these reaches no longer attain oxidized nitrogen standards, implementation measures will result in attainment of these standards by 2012. In Revolon Slough, an agricultural pollution prevention plan addressing nutrients and other pollutants will be developed in conjunction with development of the Watershed Management Plan and implementation of selected BMPs started by 2006 (following Regional Board approval of the plan). Monitoring during the implementation phase will determine whether or not Revolon Slough is achieving oxidized nitrogen standards as a result of the identified BMPs. Unless the Regional Board removes the MUN designation from Revolon Slough, additional measures beyond BMPs may be necessary to achieve the oxidized nitrogen standards. In the event the Regional Board decides not to de-designate Revolon Slough for MUN, if reductions of at least 25% in oxidized nitrogen concentrations in Revolon Slough have not been attained by 2009 (halfway through the implementation period), the TMDL should be revisited and/or additional implementation actions undertaken. Delaying attainment of oxidized nitrogen standards should not impair beneficial uses in that there is no existing or planned use of these waters for municipal water supply.

TMDL Revision Procedures

There are four conditions that could result in the revision of these TMDLs.

- Special studies conducted in the watershed demonstrate that the targets in one or more of the TMDLs are inappropriate for the Calleguas Creek watershed.
- The Calleguas Creek Watershed Management Plan demonstrates that the wasteload and load allocations, and/or the implementation plan (including schedules for attaining water quality standards) in one or more of the TMDLs are inappropriate for the watershed.
- Baseline monitoring conducted during the implementation period demonstrates substantially different conditions from those assumed in the development of the algae/dissolved oxygen and/or oxidized nitrogen TMDLs.
- Implementation measures presented in the implementation plan are insufficient to meet water quality standards.

Should any of these conditions occur, all available data will be reviewed. The sufficiency and quality of the data will be evaluated and additional information collected as deemed necessary. The information will then be utilized in the same manner as existing information was used in the development of the original TMDLs. Proposed revisions to the TMDLs resulting from the information will be developed and submitted for public comment. After public review and comment, the TMDLs will be revised as necessary to accommodate the new information. If, after review and analysis, it is determined that no changes to the TMDLs are appropriate, the public will be notified of the decision and the analysis procedure used to come to that conclusion.

Section 6. References

Ankley GT, Schubauer-Berigan MK, and Monson PD, 1995. Influence of pH and Hardness on Toxicity of Ammonia to the Amphipod *Hyalella azteca*. Can J Fish Aquat Sci. 52:2078-83.

Bachman, Steven, 2000. Spreadsheet Summary of Ag Crop Demand.

Bachman, Steven. 2001a. Nitrate Concentrations in the Las Posas Basin. Presented to the Las Posas Users Group in February, 2001.

Bachman, Steven. 2001b. Personal Communication with Ashli Cooper. 3/1/01.

Bookman-Edmonston Engineering, 1997. Feasibility Assessment: Regional Recycled Water Program in the Calleguas Service Area DRAFT. Prepared for Calleguas Municipal Water District. May 1997.

Borgmann, Uwe, 1994. Chronic Toxicity of Ammonia to the Amphipod *Hyalella azteca*; Importance of Ammonium Ion and Water Hardness. *Environmental Pollution* 86, 329-335. 1994.

Borgmann, Uwe and Borgmann, A.I., 1997. Control of Ammonia Toxicity to *Hyalella Azteca* by Sodium, Potassium and pH. *Environmental Pollution* vol. 95, No. 3 pp 325-331. 1997.

Brown Linfield C., and Barnwell, Jr. Thomas O. 1987. The Enhanced Stream Water Quality Models Qual2e and Qual2e-uncas: Documentation and User Manual. May 1997.

California Resources Agency. "CWIS 'Mugu Lagoon.'" December 1997. California Environmental Resources Evaluation System (CERES), January 8, 2001. <http://ceres.ca.gov/wetlands/geo_info/so_cal/mugu_lagoon.html>

Caupp, Craig L., Brock, James T., and Runke, Henry M., 1991. Application of the Dynamic Stream Simulation and Assessment Model (DSSAM III) to the Truckee River Below Reno, Nevada: Model Formulation and Program Description. Prepared for the Nevada Division of Environmental Protection. 1991.

Caupp, C.L., Brock, J.T., and Runke, H.M., 1997. Application of the Dynamic Stream Simulation and Assessment Model (DSSAMt) to the Truckee River Below Reno, Nevada: Model Formulation and Overview. Technical Report No. RCR96-1.1 submitted to the U.S. Bureau of Reclamation. 1997.

CH2M Hill. 1991. Final Environmental Impact Report Water Rights Application No. 29408 Petition WW-6. Prepared for City of Thousand Oaks. April 1996.

CH2M Hill. 1996. Final Subsequent Environmental Impact Report Water Rights Application No. 29408 Petition WW-6. Prepared for City of Thousand Oaks. April 1996.

CH2M HILL. 2000. Evaluation of Nutrient Standards for Malibu Creek and Malibu Lagoon. May 2000.

City of Thousand Oaks, 2000. Hill Canyon Wastewater Treatment Plant, Annual Report 1999. Thousand Oaks, CA. 2000.

Edrada, Joe. 2001. City of Thousand Oaks staff. Personal Communication with Ashli Cooper. 2/21/01.

Fugro West, Inc. 1996. Final Mitigated Negative Declaration for the Conejo Creek Diversion Project. Prepared for Camrosa Water District. Camarillo, CA. May 1996.

Goldman Charles R., and Horne Alexander J. 1994. Limnology, 2nd Edition. Mcgraw-Hill, Inc. New York. 1994, 1983.

Grigorian, Grigor. 2001. Personal Communication with Ashli Cooper. January 18, 2001.

Granade, Steve. 2001. Personal Communication with Ashli Cooper. January 16, 2001.

Kennedy/Jenks Consultants. 1999. Stochastic Model of Chloride Sources in the Calleguas Creek Watershed. DRAFT. Prepared for Fox Canyon Groundwater Management Agency & Calleguas Municipal Water District. September 1999.

Larry Walker Associates and Bookman-Edmonston Engineering, Inc. 1998. Calleguas Creek Characterization Study Monitoring Plan: Surface Water Element. Prepared for Calleguas Municipal Water District. August 1998.

Larry Walker Associates. 1999. Feasibility of Ammonia SSOs for the Los Angeles River. Prepared for the City of Burbank.

McIntyre, Sam. 2001. Personal Communication with Britton Smith. January 10, 2001.

Montgomery Watson Americas, Inc., 1995. Simi Valley County Sanitation District Report on Arroyo Simi Characterization. September 1995.

National Atmospheric Deposition Program, 2000. Website: nadp.sws.uiuc.edu/nadpdata/siteinfo.asp?id=CA42&net=NTN, station CA42.

National Research Council. 1993. Managing Wastewater in Coastal Urban Areas. National Academy Press, Washington, D.C. 1993.

Navigant, 2000. Summary of Groundwater Monitoring Results from the Calleguas Creek Characterization Study, unpublished data.

Regional Water Quality Control Board Los Angeles Region. 1994. Water Quality Control Plan: Los Angeles Region Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties. June 1994.

Regional Water Quality Control Board- Los Angeles Region, 1996a. 1996 Water Quality Assessment Data Summaries.

Regional Water Quality Control Board- Los Angeles Region, 1996b. Aesthetic Stressor Worksheet and Surface Water Quality Field Notes 1991-1996.

Schiff Kenneth and Kamer Krista, for Southern California Coastal Water Research Project. 2000. Comparison of Nutrient Inputs, Water Column Concentrations, and Macroalgal Biomass in Upper Newport Bay, California. December 21, 2000.

Seinfeld John H. 1986. Atmospheric Chemistry and Physics of Air Pollution.1986.

State Water Resources Control Board. 1988. Adoption of Policy Entitled “Sources of Drinking Water.” May 1998.

State Water Resources Control Board, 1997. Proposed Decision Regarding Application 29408 and Wastewater Change Petition No. 6 of the City of Thousand Oaks and Availability of Unappropriated Water for Applications 29816, 29819, 29581, 29959, 300317, 30092, and 30194--Arroyo Conejo, Conejo Creek, and Calleguas Creek in Ventura County. Sacramento, California. August 1997.

State Water Resources Control Board, 1999. 1998 California 303(d) List and TMDL Priority Schedule. Approved by the USEPA in May, 1999.

Thomas, Mary Ann. 2000. The Effect of Residential Development on Ground-Water Quality Near Detroit, Michigan. Journal of the American Water Resources Association. Vol. 36, no. 5. October 2000.

U.S. Geological Survey Water Resources Investigations. 1980. Ground Water in the Thousand Oaks Area, Ventura County, California. August 1980.

United States Environmental Protection Agency. 2000a. 40 Code of Federal regulations Part 130 (TMDL Rule). 2000.

United States Environmental Protection Agency Office of Air Quality. 1997. Deposition of Air Pollutants to the Great Waters, Second Report to Congress. June 1997.

United States Environmental Protection Agency Office of Water. 1985. Ambient Water Quality Criteria for Ammonia-1984. January 1985.

United States Environmental Protection Agency Office of Water. 1990. The Drinking Water Criteria Document on Nitrate/Nitrite. December 1990.

United States Environmental Protection Agency Office of Water. 1998. National Strategy for the Development of Regional Nutrient Criteria. June 1998.

United States Environmental Protection Agency. Office of Water. 1999a. Protocol for Developing Sediment TMDLs. EPA 841-B-99-004. (4503F), United States Environmental Protection Agency, Washington D.C. 132 pp.

United States Environmental Protection Agency Office of Water. 1999b. Protocol for Developing Nutrient TMDLs First Edition. November 1999.

United States Environmental Protection Agency Office of Water. 1999c. 1999 Update of Ambient Water Quality Criteria for Ammonia. December 1999.

United States Environmental Protection Agency Office of Water. 2000b. Nutrient Criteria Technical Guidance Manual: Rivers and Streams. July 2000.

United States Environmental Protection Agency Office of Water. 2000c. National Management Measures to Control Nonpoint Source Pollution from Agriculture. August 2000.

United States Environmental Protection Agency Office of Water. 2000d. Ecoregional Nutrient Criteria Fact Sheet. December 2000.

United States Environmental Protection Agency Office of Water. 2000e. Ambient Water Quality Criteria Recommendations-Rivers and Streams in Ecoregion III. December 2000.

United States Department of Agriculture, Natural Resources Conservation Service and Forest Service, 1995. Calleguas Creek Watershed Erosion and Sediment Control Plan for Mugu Lagoon. Davis, CA. May 1995.

United States Geological Survey, in press. Regional Aquifer Study.

United Water Conservation District, 2000, Surface and Groundwater Conditions Report, Water Year 1999 Supplement.

Ventura County Flood Control District, 1995. Zone III. Revised Hydrologic Analysis Calleguas Creek and Revolon Slough-Beardsley Watersheds.

Ventura County Flood Control District. 1994. Ventura County NPDES Storm Water Permit Application. April 1994.

Ventura County Flood Control District. 1994. Comprehensive Plan of the Ventura County Flood Control District. Ventura, CA. October, 1994.

Ventura County Organization of Governments. 2000 VCOG Population Forecast.

Warwick, J.J., 2000. Calleguas Creek Data Analysis in Support of TMDL Determination. Prepared for Larry Walker & Associates. July 16, 2000, with final spreadsheet added on March 19, 2001.

Welch E. B., Jacoby J.M., Horner R.R., and Seeley M.R. 1988. Nuisance Biomass Levels of Periphytic Algae in Streams. *Hydrobiolgia* **157**, 161-168. 1988.

Welch Eugene B., Quinn John M., and Hickey Christopher W. 1992. Periphyton Biomass Related to Point-Source Nutrient Enrichment in Seven New Zealand Streams. *Wat. Res.* **26**, 669-675. 1992.