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Calleguas Creek Watershed Toxicity, Chlorpyrifos and Diazinon TMDL

Technical Report

Submitted to Los Angeles Regional Water Quality Control Board

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1 Introduction

The Calleguas Creek Watershed Toxicity, Chlorpyrifos, and Diazinon Total Maximum Daily Load (Toxicity TMDL) presents the required elements for addressing impairments to Calleguas Creek and its tributaries caused by water column toxicity, sediment toxicity, organophosphate (OP) pesticides in water, and chlorpyrifos in fish tissue. The organophosphate in water and chlorpyrifos in fish tissue listings are addressed is this TMDL as they have been identified as contributing to water and sediment toxicity as described in the Problem Statement and Current Conditions sections of this TMDL. This report summarizes the analyses completed to determine the causes of these impairments, loadings from various sources, and measures to remove these impairments.

Segments of Calleguas Creek and its tributaries are impaired by water column and sediment toxicity of unknown causes, organophosphate (OP) pesticides in water, and chlorpyrifos in fish tissue (Figure 1) and are included on the California 2002 303(d) list of water quality limited segments, which was approved by the California State Water Resources Control Board (State Board) on February 4, 2003. Specifically, the 2002 303(d) list identifies impairments due to water column toxicity in Reaches 4, 5, 9B, 10, 11, and 13, sediment toxicity in Reaches 1 and 2, chlorpyrifos in fish tissue in Reaches 4 and 5, and organophosphate pesticides in water in Reach 7 (Table 1).

The Clean Water Act requires TMDLs be developed to restore impaired waterbodies, and the Porter-Cologne Water Quality Act requires that an Implementation Plan be developed to achieve water quality objectives. This document fulfills these statutory requirements and serves as the basis for amending the Water Quality Control Plan for the Los Angeles Region (Basin Plan) to achieve water quality standards in Calleguas Creek for water column and sediment toxicity, OP pesticides in water, and chlorpyrifos in fish tissue. This TMDL addresses the requirements prescribed by Section 303(d) of the Clean Water Act, 40 CFR 130.2 and 130.7, and United States Environmental Protection Agency (1991).

The Calleguas Creek Watershed Toxicity TMDL (CCW Toxicity TMDL) is based on analysis provided by Larry Walker Associates under contract to the Calleguas Creek Watershed Management Plan Steering Committee (Steering Committee) with support from the California Regional Water Quality Control Board, Los Angeles Region (Regional Board), and the USEPA, Region 9.

Table 1. Calleguas Creek Watershed Reaches on the 2002 303(d) List for Toxicity and Organophosphate Pesticides

Reach		Impairment			
		Water Column Toxicity	Sediment Toxicity	Chlorpyrifos in Fish Tissue	Organophosphate Pesticides in Water
1	Mugu Lagoon		X		
	Duck Pond Agricultural Drains/Mugu Drain/Oxnard Drain No 2		X		
2	Calleguas Creek South		X		
4	Revolon Slough	X		X	
5	Beardsley Channel	X		X	
7	Arroyo Simi				X
9B	Conejo Creek Main Stem	X			
10	Hill Canyon	X			
11	Arroyo Santa Rosa	X			
13	Conejo Creek South Fork	X			

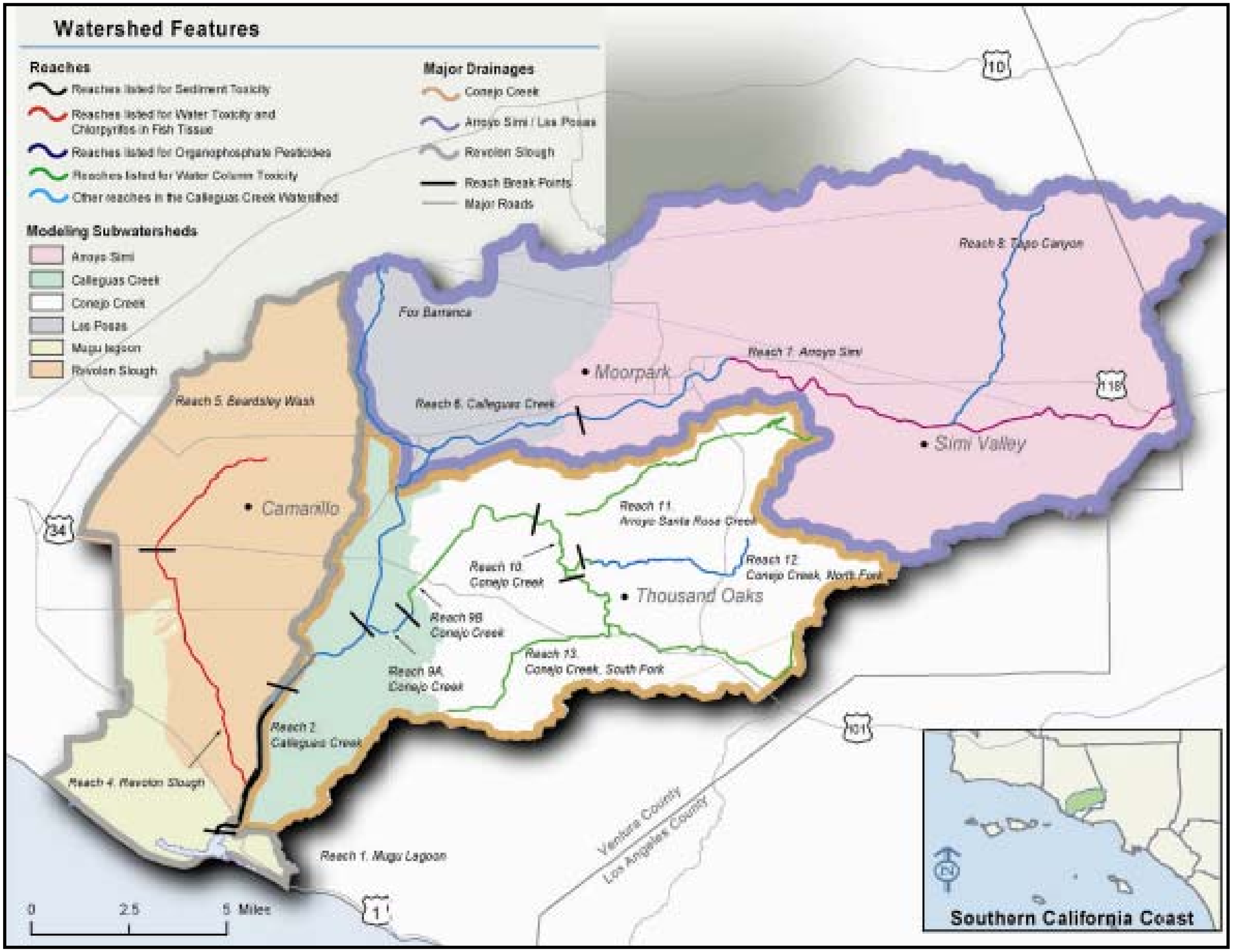

Figure 1. Reaches in the Calleguas Creek Watershed listed on the 2002 303(d) list for water or sediment toxicity, chlorpyrifos in fish tissue, and or organophosphate pesticides in water.

1.1 *Regulatory Background*

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

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

States must develop water quality management plans to implement the TMDL (40 CFR 130.6). The USEPA has oversight authority for the 303(d) program and is required to review and either approve or disapprove the TMDLs submitted by states. If the USEPA disapproves a TMDL submitted by a state, USEPA is required to establish a TMDL for that waterbody. The Regional Board identified over 700 waterbody-pollutant combinations in the Los Angeles Region where TMDLs are required (LARWQCB, 2003). A schedule for development of TMDLs in the Los Angeles Region was established in a consent decree (Heal the Bay Inc., et al. v. Browner C 98-4825 SBA) approved on March 22, 1999. The consent decree combined waterbody pollutant combinations in the Los Angeles Region into 92 TMDL analytical units. In accordance with the consent decree, this document summarizes the analyses performed and presents the TMDL for addressing analytical unit 2, which contains toxicity and chlorpyrifos in fish tissue listings, and the sediment toxicity listings presented in analytical unit 5. The remaining analytical unit 5 listings for historic pesticides as well as the PCBs listings, presented in analytical unit 7, are addressed through the CCW Organochlorine and PCBs TMDL. According to the consent decree, TMDLs addressing analytical units 2, 5, and 7 must be approved or established by USEPA by March 2006.

In addition to the federal and state regulations described above, the Regional Board enacted Resolution No. 97-10, *Support for Watershed Management in the Calleguas Creek Watershed* on April 7, 1997. Resolution 97-10 recognized watershed management as an innovative, cost-effective strategy for the protection of water quality. Resolution 97-10 also recognized that the Calleguas Creek Municipal Water District and the Publicly Owned Treatment Works (POTWs) in the Calleguas Creek Watershed had worked cooperatively with the Regional Board to develop an integrated watershed-wide monitoring program. The Calleguas Watershed Management Plan has been active since 1996 in the development of a watershed management plan for the Calleguas Creek watershed and has proactively worked with the Regional Board and the USEPA to develop TMDLs in the watershed.

1.2 *Calleguas Creek TMDL Stakeholder Participation Process*

The Calleguas Creek Watershed Management Plan has been active since 1996. In 2001, the group began discussions with the Regional Board and USEPA to provide assistance in the development of the TMDLs for the watershed. In December 2002, the group developed TMDL work plans for the majority the constituents on the 2002 303(d) list. The Toxicity TMDL Work Plan, developed with input from the

LARWQCB and USEPA, forms the basis of much of the work conducted to develop this TMDL. USEPA Region 9 approved the Toxicity TMDL Work Plan in October 2003.

The purpose of the watershed group assisting with the development of this TMDL was to take full advantage of local expertise and reach a broad group of stakeholders to resolve water quality problems within the watershed. Stakeholders include representatives of cities, counties, water districts, sanitation districts, private property owners, agricultural organizations, and environmental groups with interests in the watershed.

A high level of stakeholder involvement has occurred throughout the TMDL development process. There have been no interventions from outside groups, and much of the work has been performed, or paid for, by members of local government agencies with partial USEPA grant funding.

1.3 *Elements of a TMDL*

The Calleguas Creek Watershed Toxicity TMDL contains the following elements:

- Section 2: Problem Statement – This section presents the basis for the listings addressed by this TMDL.
- Section 3: Current Conditions – Provides a summary of current conditions based on environmental data not incorporated into the listings.
- Section 4: Numeric Targets – This section presents appropriate numeric targets that will result in the attainment of water quality objectives as well as the basis for selection of targets.
- Section 5: Source Analysis – This section presents an inventory and quantification of the sources of the pollutants of concern.
- Section 6: Linkage Analysis – This section presents the analysis developed to describe the relationship between the sources of the pollutants of concern and the resulting effect on water quality.
- Section 7: TMDL and Allocations – This section identifies the TMDL allocations for point sources (waste load allocations) and nonpoint sources (load allocations) that will result in the attainment of water quality objectives.
- Section 8: Implementation Plan – This section describes the strategy for implementing the Toxicity TMDL and achieving water quality objectives as well as a brief overview of the strategy for monitoring the effects of implementation actions.

2 Problem Statement

The Problem Statement section provides context and background for the TMDL. The environmental setting provides an overview of the hydrology, climate, and anthropogenic influences in the CCW. In addition, this section includes an overview of water quality standards for the watershed and reviews water and sediment toxicity, water quality, and fish tissue data used to develop the 1996, 1998, and 2002 303(d) listings.

2.1 *Environmental Setting*

Calleguas Creek and its tributaries are located in southeast Ventura County and a small portion of western Los Angeles County. Calleguas Creek drains an area of approximately 343 square miles from the Santa Susana Pass in the east to Mugu Lagoon in the southwest. The main surface water system drains from the mountains in the northeast part of the watershed toward the southwest where it flows through the Oxnard Plain before emptying into the Pacific Ocean through Mugu Lagoon. The watershed, which is elongated along an east-west axis, is about thirty miles long and fourteen miles wide. The Santa Susana Mountains, South Mountain, and Oak Ridge form the northern boundary of the watershed; the southern boundary is formed by the Simi Hills and Santa Monica Mountains.

Land uses in the Calleguas Creek watershed include agriculture, high and low density residential, commercial, industrial, open space, and a Naval Air Base located around Mugu Lagoon. The watershed includes the cities of Simi Valley, Moorpark, Thousand Oaks, and Camarillo. 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. The current land use in the watershed is approximately 26% agriculture, 24% urban, and 50% open space. Patches of high quality riparian habitat are present along the length of Calleguas Creek and its tributaries.

The watershed is characterized by three major subwatersheds: the Arroyo Simi/Las Posas in the north, Conejo Creek in the south and Revolon Slough in the west. Additionally, the lower watershed is also drained by several minor agricultural drains in the Oxnard plain. The following sections describe the subwatersheds in more detail. Figure 1 depicts Calleguas Creek with reach names and designations, and six smaller subwatersheds defined for analysis and modeling in this TMDL (Mugu, Revolon, Calleguas, Conejo, Arroyo Las Posas, and Arroyo Simi).

2.1.1 Arroyo Simi/Las Posas

The northern portion of the watershed is drained by the Arroyo Las Posas and the Arroyo Simi, which is tributary to the Arroyo Las Posas. The northern part of the watershed system originates in the Simi Valley and surrounding foothills. The surface flow comes from the headwaters of the Arroyo Simi at Santa Susanna pass (upper parts of Reach 7) and Tapo Canyon (Reach 8). Arroyo Simi and Arroyo Las Posas flow through the cities of Simi Valley and Moorpark and join with Calleguas Creek near Camarillo. Upstream of Simi Valley, the creek is unlined and passes through open space and recreational areas. Through the city of Simi Valley, the Arroyo Simi flows through concrete lined or rip-rapped channels. Between Simi Valley and Moorpark, a distance of approximately seven miles, the creek is unlined and without rip-rap. From the edge of Moorpark to Hitch Boulevard, 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. The Arroyo Simi flows into the Arroyo Las Posas at Hitch Blvd. Downstream of Hitch Boulevard, Arroyo Las Posas passes through agricultural fields and orchards in a primarily natural channel. Although the Arroyo Las Posas channel joins with Calleguas Creek near Camarillo, surface flow is typically not present in this portion of the channel due to evaporation and groundwater recharge upstream of Seminary Road.

Two POTWs discharge in this subwatershed. The Simi Valley Water Quality Control Plant (WQCP) discharges to the Arroyo Simi on the western edge of the City of Simi Valley. The Moorpark Wastewater Treatment Plant (WTP) discharges primarily to percolation ponds near the Arroyo Las Posas downstream of Hitch Boulevard. Direct discharges to the Arroyo Las Posas from the Moorpark WTP only occur during extremely wet periods.

2.1.2 Conejo Creek

Conejo Creek and its tributaries (Arroyo Conejo and Arroyo Santa Rosa) drain the southern portion of the watershed. Flow in the southern portion of the watershed originates in the City of Thousand Oaks and flows through the City of Camarillo before joining Calleguas Creek upstream of the California State University Channel Islands. This area supports significant residential and agricultural land uses. The following sections describe Conejo Creek and its tributaries.

2.1.2.1 Arroyo Conejo

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 Hill Canyon Wastewater Treatment Plant (WTP) discharges to the north fork of the Arroyo Conejo on the western edge of the City of Thousand Oaks. The north fork runs through Thousand Oaks upstream of the Hill Canyon WTP. 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 south fork join together about a mile upstream of the treatment plant. The joined flow (usually called the south fork at this point) and the north fork converge approximately 0.4 miles downstream of the Hill Canyon WTP. The Arroyo Conejo then flows in a natural channel through a primarily open space area until it merges with the Arroyo Santa Rosa to form Conejo Creek at the base of the canyon.

2.1.2.2 Arroyo Santa Rosa

Arroyo Santa Rosa runs on the northern edge of the City of Thousand Oaks and through agricultural land in the Santa Rosa Valley. Arroyo Santa Rosa is a natural channel for most of its length with portions of riprap and concrete lining along the sides and bottom of the channel in the vicinity of homes (such as near Las Posas Road). Prior to 1999, a wastewater treatment plant (Olsen Rd.) discharged to Arroyo Santa Rosa and maintained a constant surface flow in the reach. Since 1999, the POTW has not discharged and much of the channel is dry during non-storm events.

2.1.2.3 Conejo Creek

Arroyo Conejo and Arroyo Santa Rosa converge at the base of Hill Canyon to form Conejo Creek. Conejo Creek flows downstream approximately seven and half miles, through the City of Camarillo, to its confluence with Calleguas Creek. Just downstream of the city, the Camarillo Sanitary District Water Reclamation Plant (CSDWRP) discharges to Conejo Creek. Because the Arroyo Las Posas does not generally provide surface flow to Calleguas Creek during dry periods, Conejo Creek provides the majority of the flow in Calleguas Creek. For most of the length of the Conejo and Calleguas Creeks, the sides of the channel are rip rapped and the bottom is unlined.

2.1.3 Revolon Slough

Revolon Slough drains the agricultural land in the western portion of the watershed (Oxnard Plain). The slough does not pass through any urban areas, but does receive drainage from tributaries that drain urban areas. Revolon Slough 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 Avenue in Camarillo. The slough is concrete lined just upstream of Central Avenue and remains lined for approximately four 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 appears to be tidally influenced by inflows from Mugu Lagoon. Revolon Slough flows into Mugu Lagoon in a channel that runs parallel to Calleguas Creek. The flows from Revolon Slough and Calleguas Creek only converge in the lagoon.

In addition to Revolon Slough, a number of agricultural drains (Oxnard Drain, Mugu Drain, and Duck Pond Drain) convey agricultural and industrial drainage water to Mugu Lagoon and estuary.

2.1.4 Mugu Lagoon

Mugu Lagoon, an estuary at the mouth of Calleguas Creek, supports a diverse wildlife population including migratory birds and endangered species. This area is affected by military land uses of the Point Mugu Naval Air Weapons Station and substantial agricultural activities in the Oxnard Plain. 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) that receive some drainage from agricultural and industrial drains. In addition, multiple drainage ditches drain into the lagoon. Two of these ditches, Oxnard drainage ditches 2 and 3, discharge urban and agricultural runoff originating beyond the Station's boundaries into the central and western portion of the lagoon. The remaining ditches discharge urban and industrial runoff originating on the Station.

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. The western arm of the lagoon receives less tidal volume because of a bridge culvert that restricts the flows in that area. 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).

2.1.5 Climate and Hydrology

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). Storm events, concentrated in the wet-weather months, produce runoff of duration from one-half day to several days. Discharge during runoff from storm events is commonly 10 to 100 times greater than at other times. Storm events and the resulting high stream flows are highly seasonal, grouped heavily in the months of November through February, with an occasional major storm as early as September and as late as April. Rainfall is rare in other months, and major storm flows historically have not been observed outside the wet-weather season.

2.1.6 Surface Waters

The main surface water system drains from the mountains toward the southwest, where it flows through the Oxnard Plain before emptying to the Pacific Ocean through Mugu Lagoon. Dry weather surface water flow in the Calleguas Creek watershed is primarily composed of groundwater, municipal wastewater, urban non-storm water discharges, and agricultural runoff. In the upper reaches of the watershed, upstream of any wastewater discharges, groundwater discharge from shallow surface aquifers provides a constant base flow. Additionally, urban non-stormwater runoff and groundwater extraction for construction dewatering or remediation of contaminated aquifers contribute to the base flow. Stream flow in the upper portion of the watershed is minimal, except during and immediately after rainfall. Flow in Calleguas Creek is described as storm peaking and is typical of smaller watersheds in coastal southern California.

In the Arroyo Simi/Las Posas subwatershed, additional flow is contributed by groundwater pumped for dewatering and discharged under permit to the Arroyo Simi upstream of Madera Road. The Simi Valley WQCP discharges downstream of the City of Simi Valley and provides much of the flow in the Arroyo Simi during dry weather. During most of the year, at the point where the channel reaches Seminary Road, the surface water flow has been lost to groundwater percolation and evaporation. During and immediately following significant rains, surface flows in the Arroyo Las Posas discharge to Calleguas Creek. In the Conejo Creek subwatershed, the Hill Canyon WTP provides the majority of the surface water flow. Additionally, the Camarillo WTP provides some flow in the lower portion of Conejo Creek. Revolon Slough receives all of its flow from agricultural discharges, groundwater seepage, and some urban non-stormwater flow.

The chemical properties of surface water may influence the fate and transport of pesticides and affect toxicity of constituents to aquatic organisms. Table 2 presents the range of general water quality characteristics and summary statistics in CCW surface waters and Mugu Lagoon.

Table 2. Surface Water General Water Quality Characteristics

Water Quality Parameter	n	Mean	Std. Dev.	Maximum	Minimum	90th Percentile	10th Percentile
Freshwater Reaches							
pH	2,345	8	0.4	9.3	5	8	7
Temperature	3,911	18	5	80	5	24	12
Boron	176	5	26	183	0.1	2	0.2
Chloride	332	138	43	430	7	217	72
Hardness as CaCO3	123	658	1123	11,800	2	1347	129
Sulfate	177	410	425	2,100	5	881	88
TDS	321	1,024	730	3,930	0.8	2321	244
TSS	363	342	2112	34,800	0.1	233	1
Mugu Lagoon							
pH	60	7.8	0.5	8.8	6.2	8.4	7.1
Temperature	15	19.5	5.4	29	10	28.4	12.3
Boron	10	2	0.5	2.8	1.1	2.8	1.3
Chloride	10	7,240	3,107	14,000	4,400	11,757	3,876
Hardness as CaCO3	42	7,202	9,555	54,200	567	13,132	1,833
Sulfate	10	1,432	394	1,900	690	2,171	872
TDS	48	17,750	12,433	38,260	163	60,019	1,735
TSS	48	17.8	29	195	1	34	4

2.1.7 Groundwater

Groundwater features of the watershed are dominated by the Fox Canyon Aquifer System, which is linked to the neighboring Santa Clara River Watershed. The Fox Canyon Aquifer System is a series of deep, confined aquifers. These aquifers today receive little or no recharge from the watershed. The water quality in these aquifers is very high. However, because there is little recharge to these aquifers they suffer from overdraft. Major groundwater basins within the watershed include the Simi Basin, East Las Posas, West Las Posas, South Las Posas, Pleasant Valley, and Arroyo Santa Rosa Basins. Significant aquifers within the watershed include the Epworth Gravels, the Fox Canyon aquifer, and the Grimes Canyon aquifer in order from shallowest to deepest. In addition, the top 350 feet of sediments within the Pleasant Valley Basin are often referred to as the "Upper Zone", and are thought by some to be equivalent to the Hueneme aquifer zone that is a more well-defined and recognized layer to the west of the Pleasant Valley Basin.

Shallower, unconfined aquifers are located in the valleys of the watershed. In the upper sub-watersheds of Simi Valley and Conejo Valley, groundwater collects in the lower areas and overflows into the down-gradient valleys. The Tierra Rejada, Santa Rosa and South Las Posas valley basins are larger than the upper valley basins and are the most significant unconfined basins on the watershed. Areas of perched and unconfined groundwater are also present along the base of the Santa Monica Mountains, and overlying areas of the southeastern Oxnard Plain in the Pleasant Valley.

Water rights have not been adjudicated in many of these basins, and groundwater production is not comprehensively controlled or maintained. However, groundwater extractions are regulated in the Oxnard Plain, Pleasant Valley Basin and the Las Posas Basin by the Fox Canyon Groundwater Management Agency. In some basins, groundwater is being over-drafted and as a result Pleasant Valley has experienced subsidence. In other basins, such as the South Las Posas Basin, groundwater storage has increased significantly in the last several decades.

The chemical properties of groundwater may influence the fate and transport of pesticides and affect toxicity of constituents to aquatic organisms. The chemical solubility and sorption of these loads is largely a function of pH, redox conditions, temperature, and the presence of carbon dioxide and carbonate species. Data for many of these parameters were analyzed in groundwater samples, and the summary statistics for the results are presented in Table 3. For Calleguas Creek groundwater, temperature and Eh (redox) data were not readily available. The groundwater of the Calleguas Creek watershed is slightly alkaline, with pH typically ranging from 7.3 to 8.0, and alkalinity from 140 to 270 mg/L. Hardness also influences solubility; the analyzed Calleguas Creek groundwater samples exhibited an average hardness of 431 mg/L as $CaCO_3$. The average bicarbonate concentration was 151 mg/L. Finally, the presence of cations, often measured as electrical conductivity, can affect the sorption characteristics of infiltrating loads. As seen in Table 3, Calleguas Creek groundwater is highly heterogeneous with respect to electrical conductivity, typically ranging from 465 to 1,521 µS/cm. Consideration of these chemical properties is important when assessing the impacts of the recharge of surface waters on groundwater supplies.

Table 3. Groundwater General Water Quality Characteristics.

Water Quality Parameter	n	Mean	Std. Dev.	Maximum	Minimum	90th Percentile	10th Percentile
pH	372	7.6	0.3	10.1	7	8	7.3
Alkalinity (mg/L)	220	199	54	420	70	270	140
Hardness (mg/L, CaCO3)	76	431	136	700	132	585	235
Bicarbonate (mg/L)	79	151	99	449	7	233	8
Electrical Conductivity (µS/cm)	370	805	428	2,470	321	1,521	465

2.1.8 Anthropogenic Alterations

Historically, the Oxnard Plain served as the flood plain for Calleguas Creek. Starting in the 1850's, agriculture began to be practiced extensively in the watershed. By 1889, a straight channel from the area near the present day location of 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. Historically, Calleguas Creek was an ephemeral creek flowing only during the wet season. The cities of Simi Valley, Moorpark, Camarillo, and Thousand Oaks experienced rapid residential and commercial development beginning in the 1960s. In the early 1970s, State Water Project supplies began being delivered to the watershed. In 1957, the Camarillo Water Reclamation Plant came online, followed by the Hill Canyon WTP in Thousand Oaks in 1961. Increasing volumes of discharges from these POTWs eventually caused the Conejo/Calleguas system to become a perennial stream by 1972 (SWRCB, 1997). When the Simi Valley Water Quality Control Facility began discharging in the early 1970's, the Arroyo Simi/Arroyo Las Posas became a perennial stream that gradually flowed further downstream and currently reaches Seminary Road in Camarillo. However, surface flows from the Arroyo Simi/Arroyo Las Posas do not connect with surface flows in the Conejo Creek/Calleguas system, except during and immediately following storm events.

2.1.8.1 Sedimentation

Agricultural development and urbanization have brought about significant changes in the watershed such as increased runoff and freshwater flows, accelerated erosion and sedimentation and transport of agricultural chemicals and urban pollutants. Previous to the channelization of lower Calleguas Creek, sediment was deposited largely in a vast estuarine network that meandered across the Oxnard Plain. Numerous drop structures, channel bed stabilizers, dams, and debris basins have since been constructed to compensate for the loss of flood plain. Extensive urban development, farmland conversion, and the resulting redevelopment of orchards onto steeper slopes have changed the hydrology of the area and led to accelerated erosion rates. Accelerated erosion rates have contributed to flooding and sedimentation of the Oxnard Plain and Mugu Lagoon (NRCS, 1995).

2.1.9 Flow Diversion Project

The Conejo Creek Diversion project in the Calleguas Creek watershed diverts the majority of flow in Conejo Creek to agricultural uses in the Pleasant Valley area. The diversion project is located approximately seven miles downstream from the Hill Canyon Wastewater Treatment Plant (WTP). The water rights application allows the diversion of an amount equal to Hill Canyon's effluent minus four cubic feet per second (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 four cfs) may be diverted when at least six 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 have been reduced to less than half of the previous creek flows.

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.

2.1.10 Reach Designations

Table 4 summarizes the reach descriptions of Calleguas Creek used in this TMDL and the correlation between these reaches with the 303(d) and consent decree listed reaches. These reach designations provide greater detail than the designations in the current Basin Plan, and are developed for purposes of this TMDL. The reach revisions may provide an appropriate analytical tool for future analyses in the watershed. At this time, though, the reach revisions are not regulatory and do not alter water quality objectives for the reaches in the existing Basin Plan.

Table 4. Description of CCW Reaches Based on 2002 303(d) List

Assigned Reach No.	Reach Name Reach as Listed in 303(d) List and Consent Decree	Geographic Description	Notes: Hydrology, land uses, etc.
1 Mugu Lagoon	Mugu Lagoon	Lagoon fed by Calleguas Creek	Estuarine; brackish, contiguous with Pacific Ocean
2 Calleguas Creek South	Calleguas Creek Reach 1 and Reach 2 (Estuary to Potrero Rd.)	Downstream (south) of Potrero Rd	Tidal influence; concrete lined; tile drains; Oxnard Plain
3 Calleguas Creek North	Calleguas Creek Reach 3 (Potrero to Somis Rd.)	Potrero Rd. upstream to confluence Conejo Creek	Concrete lined ; no tidal influence; Agriculture tile drains; Pleasant Valley Basin. Camrosa WRP discharges to percolation ponds.
4 Revolon Slough	Revolon Slough Main Branch	Revolon Slough from confluence with Calleguas Creek to Central Ave	Concrete lined ; tile drains; Oxnard Plain; tidal influence
5 Beardsley Channel	Beardsley Channel	Revolon Slough upstream of Central Ave.	Concrete lined ; tile drains; Oxnard Plain
6 Arroyo Las Posas	Arroyo Las Posas Reach 1 and Reach 2 (Lewis Somis Rd. to Moorpark Fwy (23))	Confluence with Calleguas Creek to Hitch Road	Ventura Co. POTW discharge at Moorpark to percolation ponds; discharges enter shallow aquifer; dry at Calleguas confluence
7 Arroyo Simi	Arroyo Simi Reach 1 and Reach 2 (Moorpark Fwy (23) to Headwaters)	End of Arroyo Las Posas (Hitch Rd) to headwaters in Simi Valley.	Simi Valley WQCP discharge; discharges from shallow aquifers; pumped GW; GW discharges from shallow aquifers.
8 Tapo Canyon	Tapo Canyon Reach 1 and Reach 2	Confluence w/ Arroyo Simi up Tapo Cyn to headwaters	Origin near gravel mine, used by nursery, ends in residences.
9A Conejo Creek	Conejo Creek Reach 1 (Confl with Calleguas Creek to Santa Rosa Rd.)	Extends from the confluence with Arroyo Santa Rosa downstream to the Camrosa Diversion	Camarillo WTP discharge; Pleasant Valley Groundwater Basin contains both confined and unconfined perched aquifers. Groundwater and surface water used for agriculture.
9B Conejo Creek	Conejo Creek Reach 1 and Reach2 (Confl with Calleguas Creek to Tho. Oaks city limit)	Extends from Camrosa Diversion to confluence with Calleguas Creek.	Pleasant Valley Groundwater Basin contains both confined and unconfined perched aquifers. Camarillo WTP discharges to percolation ponds near downstream end.
10 Hill Canyon reach of Conejo Creek	Conejo Creek Reach 2 and Reach 3 (Santa Rosa Rd. to Lynn Rd.)	Confluence w/ Arroyo Santa Rosa to confluence w/ N. Fork; and N. Fork to just above Hill Canyon WTP	Hill Canyon WTP; stream receives N. Fork Conejo Creek surface water.
11 Arroyo Santa Rosa	Arroyo Santa Rosa	Confluence w/ Conejo Creek to headwaters	Olsen Rd. WRP; dry before Calleguas Ck confluence except during storm flow.
12 North Fork Conejo Creek	Conejo Creek Reach 3 (Tho. Oaks city limit to Lynn Rd.)	Confluence w/Conejo Creek to headwaters	
13 Arroyo Conejo (South Fork Conejo Creek)	Conejo Creek Reach 4 (Above Lynn Rd.)	Confluence w/ N. Fork to headwaters —two channels	City of Thousand Oaks; pumped/treated GW

2.2 *Water Quality Standards*

Federal law requires the states to adopt water quality standards, which are defined as the designated beneficial uses of a water segment and the water quality criteria necessary to support those uses (33 U.S.C. §1313). California implements the federal water quality standard requirements by providing for the reasonable protection of designated beneficial uses through the adoption of water quality objectives (CA Water Code §13241). Water quality objectives may be numeric values or narrative statements. For inland surface waters in the Los Angeles Region, beneficial uses, numeric and narrative objectives are identified in the Basin Plan and additional numeric objectives for toxic pollutants are contained in the California Toxics Rule as adopted by the federal EPA (40 CFR 131.38). In addition, federal regulation requires states to adopt a statewide antidegradation policy that protects high quality waters and the level of water quality necessary to maintain and protect existing uses.

2.2.1 Beneficial Uses

The Basin Plan identifies 21 existing, potential and intermittent beneficial uses for waterbodies in the CCW (Table 5). The federally defined "aquatic life" beneficial use (and the Los Angeles Region Basin Plan equivalents) is the beneficial use impaired by water column and sediment toxicity and OP pesticides. The federally defined aquatic life beneficial use encompasses the following 10 beneficial uses outlined in the Basin Plan (LARWQCB, 2002a): warm (WARM) and cold (COLD) freshwater habitats; estuarine (EST), wetland (WET) and marine (MAR) habitats; wildlife habitat (WILD); biological habitats (BIOL) including Areas of Special Biological Significance; habitats that support rare, threatened, or endangered species (RARE); habitats that support migration of aquatic organisms (MIGR); and habitats that support spawning, reproduction, and/or early development of fish (SPWN).

Table 5. Beneficial Uses in the CCW as Defined in the Water Quality Control Plan – Los Angeles Region

Waterbody	Reach[1]	Hydro Unit	Aquatic Life Beneficial Use Potentially Impacted by Toxicity and OP Pesticides										Other Beneficial Uses										
			EST	MAR	WILD	BIOL	RARE	MIGR	SPWN	WET	WARM	COLD	FRSH	NAV	REC1	REC2	COMM	MUN	IND	PROC	AGR	GWR	SHELL
Mugu Lagoon	1	403.11	E	E	E	E	E	E	E	E				E	P	E	E						E
Calleguas Creek Estuary	2	403.11	E		E		E	E	E	E				P	P	E	E						
Calleguas Creek	2, 3	403.11			E		E			E	E	E	E		E	E		P*			E	E	
Calleguas Creek	3, 9A	403.12			E						E				E	E		P*	E	E	E	E	
Revolon Slough	4	403.11			E					E	E				E	E		P*	P		E	E	
Beardsley Wash	5	403.61			E						E		E		E	E		P*					
Conejo Creek	3, 9A	403.12			E						E				E	E		P*	E	E	E	E	
Conejo Creek	9B	403.63			E				E		I		I		I	I		P*				I	
Arroyo Conejo	9A, 9B,10	403.64			E		E				I		I		I	I		P*				I	
Arroyo Conejo	13	403.68			E						I		I		I	I		P*				I	
Arroyo Santa Rosa	11	403.63			E						I		I		I	I		P*				I	
Arroyo Santa Rosa	11	403.65			E						I		I		I	I		P*				I	
North Fork Arroyo Conejo	12	403.64			E				E		E				E	E		P*			E	E	
Arroyo Las Posas	6	403.12			E						E	P			E	E		P*	P	P	P	E	
Arroyo Las Posas	6	403.62			E						E	P	E		E	E		P*	P	P	P	E	
Arroyo Simi	7	403.62			E		E				I		I		I	I		P*	I			I	
Arroyo Simi	7	403.67			E						I		I		I	I		I*	I			I	
Tapo Canyon Creek	8	403.66			E						I				I	I		I*		P	P	I	
Tapo Canyon Creek	8	403.67			E						I				I	I		I*		P	P	I	
Gillibrand Canyon Creek		403.66			E						I		I		I	I		P*				I	
Gillibrand Canyon Creek		403.67			E						I		I		I	I		P*				I	
Lake Bard		403.67			E						E				P	E		E	E	E	E	P	

[1] Reach numerical designations based on 2002 303(d) list.
E Existing Beneficial Use   P Potential Beneficial Use   I Intermittent Beneficial Use
* Municipal designations marked with an asterisk are conditional designations and are not recognized under federal law and are not water quality standards requiring TMDL development at this time. (See Letter from Alexis Strauss [USEPA] to Celeste Cantú [State Board], Feb. 15, 2002.)

2.2.2 Water Quality Objectives

The Basin Plan contains narrative water quality objectives for toxicity and pesticides. These objectives are used in developing numeric targets and allocations for TMDLs. The following narrative objectives are the most applicable for this TMDL:

Toxicity: All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in, human, plant, animal or aquatic life.

> *Effluent limits for specific toxicants can be established by the Regional Board to control toxicity identified under Toxicity Identification Evaluations (TIEs).*

There are no Basin Plan Objectives specific to sediment toxicity. However, the narrative ambient water toxicity objectives may be used to address sediment toxicity for the purposes of identifying targets for sediment toxicity.

Pesticides: No individual pesticide or combination of pesticides shall be present in concentrations that adversely affect beneficial uses. There shall be no increase in pesticide concentrations found in bottom sediments or aquatic life.

There are no adopted numeric water, sediment, or fish tissue objectives in the Basin Plan or California Toxics Rule (CTR) for any organophosphate pesticides (i.e. chlorpyrifos and diazinon).

2.2.3 Antidegradation

The state's Antidegradation Policy is contained in State Board Resolution 68-16, Statement of Policy with Respect to Maintaining High Quality Water in California. The Antidegradation Policy maintains that water quality in surface and ground waters of the state must be maintained unless it is demonstrated that a change will be consistent with the maximum benefit of the people of the state, not unreasonably affect present and anticipated beneficial use of such water, and not result in water quality less than that prescribed in water quality plans and policies. In addition to meeting state Antidegradation Policy, any actions that may result in a reduction of water quality of a water of the United States are subject to the federal Antidegradation Policy provisions contained in 40 CFR 131.12, which allows for the reduction in water quality as long as existing beneficial uses are maintained and that the lowering of water quality is necessary to accommodate economic and social development in the area.

The proposed TMDL is consistent with state and federal antidegradation policies since it does not result in a reduction of water quality.

2.3 *Basis for Listings*

The following section presents the basis for the development of the 303(d) listings related to toxicity and OP pesticides in the Watershed. The Regional Board staff conducted Water Quality Assessments (WQA) in 1996, 1998, and 2002 to identify exceedances of water quality objectives. This section discusses the data reviewed for the Water Quality Assessments and the application of the data that resulted in the 303(d) listings. For all listings except organophosphates in water, the basis of the listing was presented in the

1996 WQA. In some cases, additional data were assessed in later years, but were not used to alter the original listings. All available data used to develop listings are discussed in this section.

2.3.1 Water Column and Sediment Toxicity Listings

The following presents the available information on the development of the 303(d) listings for sediment toxicity in Reaches 1 and 2 and aquatic toxicity in Reaches 4, 5, 9B, 10, 11, and 13.

Reach: Calleguas Creek Reach 1 (Mugu Lagoon)
Formerly: Mugu Lagoon – 1996 and 1998 303(d) list
Current 303(d) listing: 2002 – Sediment Toxicity
Previous 303(d) listings: 1996 and 1998 – Sediment Toxicity
Basis: The original 1996 listing was based on information presented in the LARWQCB 1996 Water Quality Assessment Documentation (WQA). The listing of sediment toxicity in Calleguas Creek R1 on the 1996 303(d) list reads as follows: "Sed Toxicity ('93): poor survival rates[2]". The "[2]" references sediment data collected through the California State Water Resources Board's Bay Protection and Toxic Cleanup Program (BPTCP). Table 6 presents sediment toxicity data collected in 1993 by the BPTCP which are the basis for the 1996 listing.

Table 6. Sediment Toxicity Data Collected in Mugu Lagoon in 1993 by the BPTCP that Form the Basis for the Sediment Toxicity Listings in Calleguas Creek Reaches 1 and 2 and Duck Pond Agricultural Drains/Mugu Drain/Oxnard Drain No 2

Station	Stanum	Date	Mean % Survival *Eohaustorius estuarius* in homogenized sediment	Mean % survival for the *Rhepoxynius abronius* in homogenized sediment
Mugu Lagoon	44016	1/12/93	**66**	N/A
Mugu/Entrance	44054	1/12/93	N/A	**14**
Mugu/Main Lagoon	44051	1/12/93	N/A	**68**
Mugu/Western Arm	44052	1/12/93	N/A	**64**
Calleguas/Oxnard Ditch #3[1]	44050	1/12/93	**71**	N/A

1 BPTCP data is reported for Calleguas/Oxnard Ditch #3, however, in reviewing the summary report (SWRCB, 1998) and GIS coordinates the site labeled Calleguas/Oxnard Ditch #3 is actually located in Mugu Lagoon near the outfall of Oxnard Drain #2 not Oxnard Drain #3.
Bolded indicates results believed to be the basis for the listings
N/A = Not analyzed

Reach: Duck Pond Agricultural Drains/Mugu Drain/Oxnard Drain No 2
Formerly: Duck Pond Ag Drain/Mugu Drain/Oxnard Drain #2 – 1996 303(d) list; Duck Pond Agricultural Drain/Mugu Drain/Oxnard Drain #2 – 1998 303(d) list
Current 303(d) listing: 2002 – Sediment Toxicity
Previous 303(d) listings: 1996 and 1998 – Sediment Toxicity
Basis: The original 1996 listing was based on information presented in the LARWQCB 1996 WQA. The listing of sediment toxicity in Duck Pond Ag Drain/Mugu Drain/Oxnard Drain #2 on the 1996 303(d) list reads as follows: "Sed Toxicity ('93): poor survival rates[1]". The "[1]" references data collected through the California State Water Resources Board's State Mussel Watch Program (SMWP). However, no sediment toxicity data were collected through this program in the CCW. The data may not have been properly referenced in the 1996 303(d) list. The available sediment toxicity data available referenced to this site were collected by the BPTCP in 1993. The sediment toxicity samples were collected in Mugu Lagoon near the drain outfall. As the sediment toxicity samples were collected in the lagoon this listing will be

addressed as part of Mugu Lagoon. Table 6 presents sediment toxicity data collected in 1993 by the BPTCP in Mugu Lagoon which seem to be the basis for the 1996 listing in this reach.

Reach: Calleguas Creek Reach 2 (Calleguas Creek South)
Formerly: Calleguas Creek Estuary – 1996 303(d) list; Calleguas Creek R2 – Potrero Road to Broome Road – 1998 303(d) list
Current 303(d) listing: 2002 – Sediment Toxicity
Previous 303(d) listings: 1996 and 1998 – Sediment Toxicity
Basis: The original 1996 listing was based on information presented in the LARWQCB 1996 WQA. The listing of sediment toxicity in Calleguas Creek R2 on the 1996 303(d) list reads as follows: "Sed Toxicity ('93): poor survival rates[2]". The "[2]" references sediment data collected through the BPTCP. However, no BPTCP samples were collected in Reach 2. Table 6 presents sediment toxicity data collected in 1993 by the BPTCP in Mugu Lagoon which seem to be the basis for the 1996 listing in this reach.

Reach: Calleguas Creek Reach 4 (Revolon Slough)
Formerly: Revolon Slough and Beardsley Channel/Wash – 1996 303(d) list; Revolon Slough Main Branch: Mugu Lagoon to Central Avenue – 1998 303(d) list
Current 303(d) listing: 2002 – Toxicity
Previous 303(d) listings: 1996 and 1998 – Water Toxicity
Basis: The original 1996 listing was based on information presented in the LARWQCB 1996 WQA. The listing of water toxicity in Calleguas Creek Reach 4 on the 1996 303(d) list reads as follows: "Wat Toxicity: poor survival rates[5]". The "[5]" references water quality data collected for the California State Water Resources Board's 1995 draft version of the report "Final Report: Toxicity Study of the Santa Clara River, San Gabriel River, and Calleguas Creek". Table 7 presents water toxicity data collected in 1992 and 1993 by the BPTCP that are the basis for the 1996 listing. No additional data were reviewed during the water quality assessments in 1998 and 2002 for this reach. The values exceeding the narrative water quality objective for toxicity are noted in bold.

Table 7. Summary of Toxicity Test Results that Form the Basis for the Water Column Toxicity Listing on Calleguas Creek Reach 4

Parameter	Sample Date			
	7/23/92	10/23/92	1/21/93	4/2/93
Pimephales promelas				
Survival (%)	95.1	92.2	**21.7***	**27***
Growth (mg)	0.367	0.291	0.07*	0.141*
Ceriodaphnia dubia				
Survival (%)	100	**0***	100	90
Reproduction	31	0*	27.8	21.5
Selenastrum capricornutum				
Cells/mL	870000*	1400000	420000*	240000*

Bolded indicates results believed to be the basis for the listing
* Indicates significance difference from control at P ≤ 0.05; Bailey et al. 1996

Reach: Calleguas Creek Reach 5 (Beardsley Channel)
Formerly: Revolon Slough and Beardsley Channel/Wash – 1996 303(d) list; Beardsley Channel (Above Central Avenue) – 1998 303(d) list
Current 303(d) listing: 2002 – Toxicity
Previous 303(d) listings: 1996 and 1998 – Water Toxicity

Basis: The original 1996 listing was based on information presented in the LARWQCB 1996 WQA. The listing of water toxicity in Calleguas Creek Reach 5 on the 1996 303(d) list reads as follows: "Wat Toxicity: poor survival rates[5]". The "[5]" references water quality data collected for the California State Water Resources Board's 1995 draft version of the report "Final Report: Toxicity Study of the Santa Clara River, San Gabriel River, and Calleguas Creek". Table 8 presents water toxicity data collected in 1992 and 1993 by the BPTCP that are the basis for the 1996 listing. No additional data were reviewed during the water quality assessments in 1998 and 2002 for this reach. The values exceeding the narrative water quality objective for toxicity are noted in bold.

Table 8. Summary of Toxicity Test Results that Form the Basis for the Water Column Toxicity Listing on Calleguas Creek Reach 5

Parameter	Sample Date			
	7/23/92	10/23/92	1/21/93	4/2/93
Pimephales promelas				
Survival (%)	**68.2***	93.5	76.7	96.7
Growth (mg)	0.251*	0.35	0.445	0.419
Ceriodaphnia dubia				
Survival (%)	100	**0***	**0***	**0***
Reproduction	36.9	0.11*	0*	0*
Selenastrum capricornutum				
Cells/mL	150000	1600000	390000	570000

Bolded indicates results believed to be the basis for the listing * Indicates significance difference from control at P ≤ 0.05; Bailey et al. 1996

Reach: Calleguas Creek Reach 9B (Conejo Creek Main Stem)

Formerly: Conejo Creek/Arroyo Conejo – 1996 303(d) list; Part of Conejo Creek Reaches 1 and 2 – 1998 303(d) list

Current 303(d) listing: 2002 – Toxicity

Previous 303(d) listings: 1996 and 1998 – Water Toxicity

Basis: The listing of water toxicity in Calleguas Creek Reach 9B on the 1996 303(d) list reads as follows: "Wat Toxicity: poor survival rates[5]". The "[5]" references water quality data collected for the California State Water Resources Board's 1995 draft version of the report "Final Report: Toxicity Study of the Santa Clara River, San Gabriel River, and Calleguas Creek". On the 1996 303(d) list, Calleguas Creek Reaches 9A, 9B, 10, and 13 were all one reach. In 1998 and 2002 when the reaches for Calleguas Creek were redefined, the 1996 listings were applied to all of the reaches unless data were available to demonstrate that the reach should not be listed. Consequently, listing data are not available for each of these reaches specifically. The data used to list all of the reaches were collected in what is now called Calleguas Creek Reach 9A (Conejo Creek). Table 9 presents water toxicity data collected in 1992 and 1993 that are the basis for the 1996 listing. No additional data were reviewed during the water quality assessments in 1998 and 2002 for this reach. The values exceeding the narrative water quality objective for toxicity are noted in bold.

Table 9. Summary of Toxicity Test Results that Form the Basis for the Water Column Toxicity Listing on Calleguas Creek Reach 9B

Parameter	Sample Date			
	7/23/92	10/23/92	1/21/93	4/2/93
Pimephales promelas				
Survival (%)	95	**76.6***	96.7	91.7
Growth (mg)	0.337*	0.226*	0.426	0.313
Ceriodaphnia dubia				
Survival (%)	**0***	**0***	100	100
Reproduction	0.4*	0*	25.7	25.8
Selenastrum capricornutum				
Cells/mL	61000*	1020000	1500000*	110000

Bolded indicates results believed to be the basis for the listing * Indicates significance difference from control at P ≤ 0.05; Bailey et al. 1996

Reach: Calleguas Creek Reach 10 (Hill Canyon Reach of Conejo Creek)
Formerly: Conejo Creek/Arroyo Conejo– 1996 303(d) list; Part of Conejo Creek Reaches 2 and 3 – 1998 303(d) list
Current 303(d) listing: 2002 – Toxicity
Previous Listings: 1996 and 1998 – Water Toxicity
Basis: The original 1996 listing was based on information presented in the LARWQCB 1996 WQA. The listing of water toxicity in Calleguas Creek Reach 10 on the 1996 303(d) list reads as follows: "Wat Toxicity: poor survival rates[5]". The "[5]" references water quality data collected for the California State Water Resources Board's 1995 draft version of the report "Final Report: Toxicity Study of the Santa Clara River, San Gabriel River, and Calleguas Creek". On the 1996 303(d) list, Calleguas Creek Reaches 9A, 9B, 10, and 13 were all one reach. In 1998 and 2002 when the reaches for Calleguas Creek were redefined, the 1996 listings were applied to all of the reaches unless data were available to demonstrate that the reach should not be listed. Consequently, listing data are not available for each of these reaches specifically. The data used to list all of the reaches were collected in what is now called Calleguas Creek Reach 9A (Conejo Creek). Table 9 presents water toxicity data collected in 1992 and 1993 that are the basis for the 1996 listing. No additional data were reviewed during the water quality assessments in 1998 and 2002 for this reach. The values exceeding the narrative water quality objective for toxicity are noted in bold.

Reach: Calleguas Creek Reach 11 (Arroyo Santa Rosa)
Formerly: Arroyo Santa Rosa Reaches 1 and 2 – 1996 and 1998 303(d) lists
Current 303(d) listing: 2002 – Toxicity
Previous 303(d) listings: No previous listings for water column toxicity.
Basis: In the 1996 and 1998 WQA, this reach was not assessed and no listings were placed on the 1996 and 1998 303(d) lists. In 2002, toxicity was added to the 303(d) list as a result of the redefinition of reaches.

Reach: Calleguas Creek Reach 13 (South Fork Conejo Creek)
Formerly: Conejo Creek/Arroyo Conejo – 1996 303(d) list; Part of Conejo Creek Reaches 3 and 4 – 1998 303(d) list
Current 303(d) listing: 2002 – Toxicity
Previous 303(d) listings: 1996 and 1998 Water Toxicity

Basis: The original 1996 listing was based on information presented in the LARWQCB 1996 WQA. The listing of water toxicity in Calleguas Creek Reach 13 on the 1996 303(d) list reads as follows: "Wat Toxicity: poor survival rates[5]". The "[5]" references water quality data collected for the California State Water Resources Board's 1995 draft version of the report "Final Report: Toxicity Study of the Santa Clara River, San Gabriel River, and Calleguas Creek". On the 1996 303(d) list, Calleguas Creek Reaches 9A, 9B, 10, and 13 were all one reach. In 1998 and 2002 when the reaches for Calleguas Creek were redefined, the 1996 listings were applied to all of the reaches unless data were available to demonstrate that the reach should not be listed. Consequently, listing data are not available for each of these reaches specifically. The data used to list all of the reaches were collected in what is now called Calleguas Creek Reach 9A (Conejo Creek). Table 9 presents water toxicity data collected in 1992 and 1993 that are the basis for the 1996 listing. No additional data were reviewed during the water quality assessments in 1998 and 2002 for this reach. The values exceeding the narrative water quality objective for toxicity are noted in bold.

2.3.2 Organophosphate Pesticides in Water Listing

The following presents the available information on the development of the 303(d) listing for organophosphate pesticides in water in Reach 7.

Reach: Calleguas Creek Reach 7 (Arroyo Simi)
Formerly: Arroyo Simi and a portion of Arroyo Las Posas – 1996 303(d) list; Arroyo Simi Reaches 1 and 2 and a portion of Arroyo Las Posas Reach 2 – 1998 303(d) list
Current 303(d) listing: Organophosphate Pesticides
Previous 303(d) listings: No previous listings for organophosphates.
Basis: The 2002 listing reads as follows: "Organophosphate Pesticides." This listing was based on information presented in the LARWQCB 2002 Water Body Fact Sheets Supporting the Section 303(d) Recommendations. The listing is based on 22 water samples, in which toxicity was documented in 1998-99. Subsequent chemistry and toxicity identification evaluations (TIEs) identified ammonia, chlorpyrifos and diazinon.

During the Calleguas Creek Characterization Study (CCCS) (LWA, 2000) completed in 1999, six samples were analyzed for toxicity, and 12 samples were analyzed for organics in Reach 7. Of the six samples analyzed for toxicity, *Ceriodaphnia dubia* mortality and diminished reproduction was observed in 67% of the samples. *Pimephales promelas* mortality and diminished growth were also observed in 83% of the samples. Of the 12 samples analyzed for organics, one sample exceeded the CDFG diazinon chronic criterion (0.05 ug/L), two exceeded the CDFG (0.08 ug/L) acute criterion, and three exceeded the USEPA (0.1 ug/L) acute criterion. There were no detected exceedances of the USEPA or CDFG chlorpyrifos criteria. In addition, a study completed by Anderson et al. (2002), presented results of TIEs conducted on two Arroyo Simi samples, suggesting diazinon was the cause of toxicity. The 2002 organophosphate pesticide listings are based on both toxicity and water chemistry data for pesticides that exceed the narrative toxicity and narrative pesticide objectives in the Basin Plan.

2.3.3 Chlorpyrifos in Fish Tissue Listings

The following presents the available information on the development of the 303(d) listings for chlorpyrifos in fish tissue in Reaches 4 and 5.

Reach: Calleguas Creek Reach 4 (Revolon Slough)
Formerly: Revolon Slough and Beardsley Channel/Wash – 1996 303(d) list; Revolon Slough Main Branch: Mugu Lagoon to Central Avenue – 1998 303(d) list
Current 303(d) listing: Chlorpyrifos (tissue)
Previous Listings:
1996 – Elevated Tissue Levels (Chlorpyrifos)
1998 – Chlorpyrifos Elevated levels of Chlorpyrifos in tissue.
Basis: In 1996, chlorpyrifos in fish tissue was listed based on the 1996 WQA. The 1996 listing of chlorpyrifos in fish tissue in Revolon Slough in the WQA reads as follows: "Tissue ('93): chlorpyrifos (EDL95)[3]". The "[3]" references that the data were collected through the California State Water Resources Board's Toxic Substances Monitoring Program (TSMP). The EDL95 (Elevated Data Level 95%) represents the "standard" that was exceeded. Table 10 presents fish tissue data collected by the TSMP in 1993 that are the basis for the 1996 listing. These data were collected on Revolon Slough at Wood Road from a combined sample of 22 *Pimephales promelas*. Additional data, presented in Table 10, were collected on Revolon Slough at Wood Road in 1994 and 1997. The elevated levels of chlorpyrifos in tissue are highlighted in bold in the table.

Table 10. Summary of Chlorpyrifos Fish Tissue Data Collected by the TSMP in Revolon Slough at Wood Road

Sample Date	Wet Chemical Tissue Concentrations	Lipid Weight Organic Chemical Tissue Concentrations
6/20/1993	**100 ppb**	**1900 ppb**
6/23/1994	10 ppb	166 ppb
7/16/1997	18 ppb	250 ppb

Bolded indicates results believed to be the basis for the listing **Note:** *Pimephales promelas* (fathead minnow) was the test species.

Reach: Calleguas Creek Reach 5 (Beardsley Channel)
Formerly: Revolon Slough and Beardsley Channel/Wash – 1996 303(d) list; Beardsley Channel (Above Central Avenue) – 1998 303(d) list
Current 303(d) listing: Chlorpyrifos (tissue)
Previous Listings:
1996 – Elevated Tissue Levels (Chlorpyrifos)
1998 – Chlorpyrifos Elevated levels of chlorpyrifos in tissue.
Basis: In the 1996 303(d) list, Beardsley Wash and Revolon Slough were combined as one reach. In 1998, when the two reaches were separated, the listings from Revolon Slough were applied to Beardsley Wash unless data were available to demonstrate that the listing was not applicable. Because the only data available for these two reaches were those collected at Wood Road on Reach 4, the data presented in Table 10 form the basis of this listing.

2.3.4 Use of EDLs to Form the Basis of 303(d) Listings

As described in the 1996 WQA, "Fish tissue Elevated Data Level (EDL) values are an internal state comparative measure that ranks a given concentration of a particular substance with previous data from the state programs. EDLs are calculated by ranking all of the results for a given chemical from the highest concentration measured down to and including those records where the chemical is not detected." An EDL value of 95 (EDL95) indicates that the pollutant concentration in fish tissue found in that particular sample is higher than the pollutant concentrations found in 95% of fish tissue samples collected throughout the state. Guidance presented in the LARWQCB 303(d) listing Staff Reports in 1998 and 2002 (LARWQCB, 1998;

2002a) indicate EDLs alone are not sufficient assessment guidelines for determining impairment, and listings based solely on EDL exceedances should be removed from the 303(d) list. Although other EDL based listings were removed in 1998 and 2002 as a result of this guidance, the chlorpyrifos in fish tissue listing remained on the list, likely as a result of concerns about water column concentrations of these pollutants. In 1997, chlorpyrifos was identified as contributing to *C. dubia* mortality in samples collected from Revolon Slough and Beardsley Channel (Anderson et al., 2001)

At the time the samples were collected (1993) on which the listings were based, analytical methods at contract laboratories could not measure chlorpyrifos in water at sufficiently low detection limits to identify it at levels at or below water quality criteria. However, analytical methods have now progressed to the point at which water column concentrations of these pollutants can be detected at levels of concern. As presented in the following Current Conditions section, water chemistry samples collected through various programs in Revolon Slough (1995 through 2004) have indicated the presence of chlorpyrifos exceeding water quality criteria.

Because the state of the science in measuring pesticides in water has advanced from the time of the initial listing this TMDL focuses on identifying targets that prevent exceedances of the narrative pesticide and toxicity standards in water as well as numeric chlorpyrifos water quality criteria. The monitoring program of this TMDL will evaluate the adequacy of the water column targets to address the fish tissue listings. If necessary, the Regional Board can revise the numeric targets during the implementation period of the TMDL.

2.4 *Problem Statement Summary*

All of the listings presented in this Problem Statement section and in summary in Table 11 will be addressed by this TMDL.

Table 11. Calleguas Creek Watershed Reaches on the 2002 303(d) List for Toxicity and Organophosphate Pesticides

Reach		Impairment			
		Water Column Toxicity	Sediment Toxicity	Chlorpyrifos in Fish Tissue	Organophosphate Pesticides in Water
1	Mugu Lagoon		X		
1	Duck Pond Agricultural Drains/Mugu Drain/Oxnard Drain No 2		X		
2	Calleguas Creek South		X		
4	Revolon Slough	X		X	
5	Beardsley Channel	X		X	
7	Arroyo Simi				X
9B	Conejo Creek Main Stem	X			
10	Hill Canyon	X			
11	Arroyo Santa Rosa	X			
13	Conejo Creek South Fork	X			

3 Current Conditions

Since the mid-1990's various studies have been conducted to assess water and sediment quality in the CCW. Portions of the data collected through these studies were incorporated in to the 1996, 1998, and 2002 WQAs to identify exceedances of water quality objectives. The portion of the available data that formed the basis of the listings was presented in the Problem Statement section. The purpose of the Current Conditions section is to present relevant environmental monitoring data that may not have been included in the WQAs. Relevant environmental monitoring data collected in each reach of the CCW are presented in this section. These environmental monitoring data include, where available:

1. Water toxicity data;
2. Sediment toxicity data;
3. Toxicant identification evaluation (TIE) summaries;
4. Water chemistry data; and,
5. Sediment chemistry data.

3.1 *Use of Environmental Data in Current Conditions Section*

Where possible, constituents responsible for contributing to water and/or sediment toxicity are identified. Water and sediment quality data presented below describe constituents identified as contributing to toxicity in a given reach based on TIEs. Chlorpyrifos and/or diazinon water quality data are also presented because several reaches are on the 2002 303(d) list for these constituents. Receiving water quality data have been gathered through a variety of monitoring programs and incorporated in the CCW Database (LWA, 2004a). Table 12 presents the studies and associated data type used to develop the Current Conditions section.

Table 12. Summary Table of Data Sources Used to Develop Toxicity TMDL Current Conditions Section

Data Source[1]	Begin Date	End Date	Chlorpyrifos and/or Diazinon Data	Toxicity Data
205(j) Non Point Source Study (LWA, 2004a)	11/98	5/99	W	
Bay Protection Toxic Cleanup Program – BPTCP (SWRCB, 1998)	6/96	2/97	S	S
Calleguas Creek Characterization Study – CCCS (LWA, 2000)	7/98	5/99	W, S	W, S
Calleguas Creek Watershed TMDL Work Plan Monitoring Plans (LWA, 2004)	8/03	8/04	W, S	W, S
Camarillo Wastewater Treatment Plant NPDES Monitoring (City of Camarillo, 1997-2000)	2/97	8/00	W	
City of Thousand Oaks Department of Water (City of Thousand Oaks, 1997-2001)	2/97	8/01	W	
State Mussel Watch Program – SMWP (SWRCB, 2004a)	1/89	9/92	S	
Toxic Substance Monitoring Program – TSMP (SWRCB, 2004b)	4/85	8/00	S	
United States Navy (personal communication, Granade)	1/94	6/02	W	S
University of California Davis Study (Anderson *et al.*, 2002)	3/95	6/99	W	W
University of California Los Angeles Study (Abrol *et al.*, 2003)	7/99	7/99[2]	W	
Ventura County Watershed Protection District – VCWPD (VCWPD 1998-2004)	1/98	2/04	W	W

1 Complete references for these studies are provided in the References section of this report when available.
2 Receiving water samples were only collected on one day through this program.
W Represents samples collected in water.
S Represents samples collected in sediments.

The following four studies are repeatedly discussed in this section and have been abbreviated as follows:

1. A University of California Davis Study referred to as "UC Davis Study" (Anderson et al., 2002). Two errors were found in the reported values for chlorpyrifos in water in the text of this study. In conferring with the primary author (B. Anderson, pers. comm. 2004), the correct values were identified and included in this document and the watershed database.
2. Ventura County Watershed Protection District NPDES stormwater monitoring program reports and data referred to as "VCWPD" (VCWPD, 1998 through 2004).
3. Calleguas Creek Characterization Study referred to as "CCCS" (LWA, 2000).
4. CCW TMDL Work Plan Monitoring Plans referred to as "TMDL Work Plan" (LWA, 2004a).

Where toxicity is discussed the word "observed" is used to describe a significant toxic response in an environmental sample. A toxic response was considered significant when the environmental sample response was significantly different than the control treatment response at the 95% confidence level ($p < 0.05$). For the purposes of this TMDL acute endpoints refer to mortality and chronic endpoints refer to growth, reproduction, and/or fertilization. Chronic endpoints are presented when available. In instances where mortality was 100%, chronic endpoints were not measured. Because some toxicity tests were set up only to measure acute endpoints (mortality) the number of acute and chronic tests may differ.

Development of this TMDL included monitoring of a variety of constituents in water, sediment, and fish tissue during 2003-2004 (referred to as TMDL Work Plan monitoring). The purpose of TMDL Work Plan monitoring was to augment previously existing data for the CCW, which contained a high proportion of non-detected values and very few sampling events occurring concurrently across mediums (water, sediment, fish tissue). Analysis of TMDL Work Plan samples used methods with lower detection limits than much of the previously existing data and included several events with concurrent water, fish tissue, and sediment monitoring. These data significantly improve understanding of current conditions in the CCW and also improve the capability for data analysis and modeling.

3.1.1 Development of Summary Statistics

A large proportion of data used to develop the summary statistics for this TMDL are non-detected data. There are three classes of procedures to handle non-detected data: 1) simple substitution, 2) distributional, and 3) robust methods. A full discussion of the three procedures can be found in *Statistical Methods in Water Resources* (Helsel and Hirsch, 1992). While the simple substitution method is widely used, there is no theoretical basis for its use. Data used in the Toxicity TMDL development were collected over time and by different programs, so there are a variety of non-detected levels. The non-detect levels are comparable to the maximum measured values and one-half the higher non-detect levels are greater than the median of the data sets. Simple substitution is not used in the data analysis. Distributional methods force both measured data and non-detects to follow an assumed distribution type. So long as the data follow the assumed distribution, unbiased estimates of summary statistics can be calculated, however, if the data do not exactly follow the assumed distribution, there will be a bias to summary statistics. Robust methods use the measured data to estimate an assumed distribution that is then used to fill-in the non-detect values. The fill-in non-detects are only used to estimate summary statistics and are not considered estimates of specific samples. The robust methods use the collection of measured values and fill-in non-detects to calculate the summary statistics. Robust methods are not as sensitive to the choice of assumed distribution as the distributional method, and summary statistics can be directly calculated using fill-in values. Because the non-detect data are filled-in after the distribution is calculated, multiple non-detect levels are easily handled by the method. The robust method of regression on order statistics (ROS) is used in the data analysis for the Toxicity TMDL to provide a statistically defensible analytical procedure and to protect against potential errors of a distributional method.

The robust method ROS is used to incorporate non-detect information in the analyses performed for the Toxicity TMDL. A log-normal distribution is flexible in shape providing reasonable approximations to data which are nearly symmetric (normally distributed) as well as positively-skewed distributions (Helsel and Hirch, 1992). The log-normal distribution is widely used in practice to represent environmental data [California State Implementation Plan (SWRCB, 2000) and USEPA's Technical Support Document (1991)]. ROS utilizes the measured data (uncensored) in an analysis to estimate the log-normal distribution of the concentrations (Helsel, 1988, 1990). The initial step of the ROS method is to calculate probability-plotting positions (i.e. z-scores or standard deviates) for each data point (censored and uncensored) based on the ordering of all data. A least-squares regression is performed to fit a regression of the log-transformed measured values to their probability plotting positions there-by defining the best fit log-normal distribution to the data. The censored data (non-detects) are assigned values based on their probability plotting positions and the calculated distribution (Helsel, 1990 and Shumway, 2002). Summary statistics are then calculated based on the uncensored data points and the filled-in censored values. Criteria for sufficient data to use the ROS method are: 1) at least 20% and preferably 50% detected data and 2) at least three unique detected values. Instances of insufficient detected data are marked in the summary statistics tables.

Because of limited available data, grab and composite samples are treated in the analysis as equivalent and equally representative of the sampled water, also estimated and qualified data are used as normal detected values. Both uses of the data may introduce errors into the analysis, as grab samples may not be equivalent to composite samples and may not be representative of the targeted source type, and estimated values, while being a better estimate of the true value than the reporting limit, may not reflect the true value in the water accurately.

3.1.1.1 Environmental Data Used

The current condition summary statistics tables presented for each reach consider only more recent data collected from 1995-2004. This time frame is selected for these tables because the first 303(d) listings in the CCW were in 1996 and also because detection limits improved significantly during this time period. Water chemistry data collected in receiving waters in the CCW and compiled in the CCW Database (LWA, 2004a) were used to develop the current conditions summary statistics. In one instance water samples collected during a storm event were split and analyzed as filtrate and filtered solids. The measured values of the filtrate and filtered solids were combined as a total value before statistical analysis was conducted. This was done so the stormwater data would be comparable to the remaining data which had been analyzed as whole samples.

Sediment chemistry data collected in receiving waters in the CCW and compiled in the CCW Database (LWA, 2004a) were used to develop the current conditions summary statistics. Only sediment samples identified as collected at a depth interval beginning at zero were considered as sediment toxicity samples are collected from the upper two to three centimeters of the streambed. Samples with no depth indicated were also considered as it was assumed if no depth was indicated in the original data source samples were collected from the top of the streambed. During two sediment sampling events, sediment samples were split into two grain size fractions and analyzed separately. The measured values of the two grain size fractions were combined based on the percent grain size in each fraction before statistical analysis was conducted. This was done so these sediment data would be comparable to the remaining data which had been analyzed as whole samples.

The bulk of the data from the sources cited in Table 12 were used in this analysis. A large proportion of data used to develop the summary statistics for this section are non-detected data. However, as mentioned directly above, the ROS method has defined data requirements for developing summary statistics. Due to the number of non-detected values at relatively high detection limits the ability to develop summary statistics was limited. To develop summary statistics to characterize water quality in each reach non-detected samples were removed when detection limits were higher than concentrations considered characteristic of the reach based on detected values. Table 13 presents the number of samples removed by reach and site as well as the range of detection limits removed. No sediment chemistry results were removed as a result of non-detect values at high detection limits.

Table 13. Number of Non-Detect Values Removed Due to High Detection Limits from Receiving Water Sampling Sites

Reach	Site	Number of Non-Detect Samples Removed due to High DLs		Range of Removed DLs (ug/L)	
		Diazinon	Chlorpyrifos	Diazinon	Chlorpyrifos
3	Camarillo – W-15	2	0	2	
	VCWPD – ME-CC	12	12	2	2
9B	Camarillo – W-16	2	0	2	
10	Hill Canyon – W-18	10	10	1 - 2	1.5 - 2
	Hill Canyon – W-19	11	11	1 - 2	1.5 - 2
11	Olsen Rd – W-17	14	11	1 - 2	1.5 - 2
Total Number Removed		**51**	**44**		

3.2 *Current Conditions by Reach*

Reach: Calleguas Creek Reach 1 (Mugu Lagoon)

Mugu Lagoon is listed on the 2002 303(d) list for sediment toxicity based on toxicity tests conducted as part of the BPTCP in 1993.

Sediment Toxicity

Studies conducted by the BPTCP (SWRCB, 1998), the Navy (Tetra Tech, 2000; 2003), and UCLA (Anghera, 2004) have analyzed bulk sediment samples for toxicity in Mugu Lagoon. Bulk sediment samples have been analyzed for toxicity to the amphipods *Eohaustorius estuarius, Ampelisca abdita,* and *Rhepoxynius abronius,* and the polychaete *Neanthes arenceodenta*. Because of several differences in methodologies among these studies (e.g. sample collection, test methods) the studies are not directly comparable and the analysis of these studies is solely qualitative.

Significant mortality to *R. abronius* was observed in 1994 by the BPTCP at the Mugu Entrance station and *E. estuarius* in 1997 at the Central Mugu Lagoon – B1 station (see map in Appendix I). Studies conducted by the Navy in 1994 observed significant mortality to *E. estuarius* (at Site 2) and *A. abdita* (at Site 5) (see map in Appendix I). Additionally, mean weight of *N. arenceodenta* was significantly decreased at Site 2. In 1997, the Navy performed a follow-up validation study to the toxicity observed in 1994. Sediment toxicity tests using *A. abdita* were performed at eight stations at Site 11 and at eight identified reference stations. Although mortality was high at several stations, statistical comparison of the mortality results showed no significant difference between Site 11 and the reference stations. As part of a UCLA graduate study several toxicity tests were performed using *E. estuarius*. High mortality (greater than 50%) was observed at several stations, however, the report did not present results based on significant difference from control organisms. Complete mortality was observed at two sites on Creek A (see map in Appendix I).

Outside of collecting sediment chemistry data, none of the above referenced studies gathered additional information to conclusively identify the constituent(s) causing observed toxicity. However, sediment chemistry data collected during these studies were compared to sediment quality guidelines. The guidelines are values used to interpret the relationship between sediment chemistry and biological impacts. Based on this evaluation, presented in Appendix I, constituents that have exceeded guidelines that may be considered for investigation through future monitoring in Mugu Lagoon include: total chlordane, PCBs, DDD, DDT, DDE, arsenic, cadmium, copper, lead, nickel, and zinc. Appendix I presents a more detailed description of the available Mugu Lagoon data as well as the comparison to sediment quality guidelines.

Reach: Calleguas Creek Reach 2 (Calleguas Creek South)

Calleguas Creek South is listed on the 2002 303(d) list for sediment toxicity. In addition, water quality data have indicated the presence of chlorpyrifos and diazinon (Table 14).

Table 14. Summary Statistics for Relevant Water Quality Data in CCW Reach 2

Constituent	n	% Detected	Number Detected	Units	Range of Detection Limits	Mean	Standard Deviation	Median	Maximum Detected Value	% Above Criteria[1,2]
Chlorpyrifos	12	17%	2	ug/L	0.005-0.05	NA	NA	NA	0.481	17%
Diazinon	12	67%	8	ug/L	0.005-0.05	0.087	0.111	0.045	0.356	17%

1 % Above Criteria is calculated using only detected values that exceeded the criteria. These values could be higher because not all samples were tested at detection limits below numeric targets.
2 Criteria used: Chlorpyrifos CDFG chronic (0.014 ug/L) Diazinon: USEPA chronic and acute (0.10 ug/L).
NA Insufficient detected data to develop some summary statistics

Sediment Toxicity

Studies conducted through two programs (CCCS and TMDL Work Plan) have analyzed sediment samples for toxicity in this reach. A total of four bulk sediment samples have been analyzed for toxicity to *E. estuarius* and two bulk sediment samples have been analyzed for toxicity to *H. azteca*. In two porewater samples analyzed for toxicity to *C. dubia*, mortality was observed in one sample and reproductive toxicity was observed in the other sample. Mortality of *H. azteca* was observed in one of the two samples (50%). Mortality of *E. estuarius* was observed in three of the four samples (75%). In two of these three samples, toxicity was not above the established trigger level (>50% survival toxicity) set in the TMDL Work Plan monitoring program for further investigation. The other sample was above the trigger and sediment porewater toxicity testing was performed before initiating Phase I TIE procedures on the porewater. However, a Phase I TIE was not performed on this sample as the porewater from this sample was not toxic to *E. estuarius* survival.

Based on the available information, it is not clear which pollutant(s) are contributing to sediment toxicity in this reach. As such no sediment chemistry data are provided.

Reach: Calleguas Creek Reach 3 (Calleguas Creek)

Calleguas Creek is not listed on the 2002 303(d) list for water or sediment toxicity. However, studies have identified occurrences of water and sediment toxicity to various test organisms in samples collected in this reach (CCCS and VCWPD). In addition, water quality data have indicated the presence of chlorpyrifos and diazinon. The following is a discussion of current conditions as they relate to the presence of chlorpyrifos and diazinon in water and water and sediment toxicity in this reach. Table 15 presents relevant summary statistics for water quality data.

Water Toxicity

Studies conducted through three programs (VCWPD, CCCS, and TMDL Work Plan) have analyzed water samples for toxicity in this reach. A total of 28 samples have been analyzed for toxicity to *C. dubia*, 10 samples have been analyzed for toxicity to *Menidia beryllina*, and six samples have been analyzed for toxicity to *Pimephales promelas*. Mortality to *M. beryllina* was observed in one sample (10%). No mortality or growth toxicity were observed in any of the *P. promelas* samples. *C. dubia* mortality was observed in eight of 28 samples (29%) and reproductive toxicity was observed in seven of 16 samples (44%).

One TIE was conducted in this reach through the TMDL Work Plan. This TIE was initiated on the sample immediately after it was received by the laboratory in an attempt to characterize degrading toxicity observed in the previous sample collected in this reach. Reproductive toxicity to *C. dubia* was observed in this sample but mortality was not. However, in the TIE sample treated with piperonyl butoxide (PBO), significant mortality and reproductive toxicity were observed. PBO is used to inhibit the metabolism of a test species to eliminate toxicity related to metabolically activated compounds such as diazinon and chlorpyrifos. The presence of toxicity in the PBO treated sample suggests that a compound detoxified through the test species' metabolism was present at sub-lethal levels.

Based on the available information, it is not clear what pollutant(s) are contributing to water toxicity in this reach.

Table 15. Summary Statistics for Relevant Water Quality Data in Reach 3

Constituent	n	% Detected	Number Detected	Units	Range of Detection Limits	Mean	Standard Deviation	Median	Maximum Detected Value	% Above Criteria[1,2]
Chlorpyrifos	25	32%	8	ug/L	0.005-0.250	0.027	0.080	0.005	0.405	24%
Diazinon	30	53%	16	ug/L	0.005-0.250	0.060	0.074	0.031	0.280	13%

1 % Above Criteria is calculated using only detected values that exceeded the criteria. These values could be higher because not all samples were tested at detection limits below numeric targets.
2 Criteria used: Chlorpyrifos CDFG chronic (0.014 ug/L) Diazinon: USEPA chronic and acute (0.10 ug/L).

Sediment Toxicity

Studies conducted through two programs (CCCS and TMDL Work Plan) have analyzed sediment samples for toxicity in this reach. A total of six bulk sediment samples have been analyzed for toxicity to *H. azteca*. In two porewater samples analyzed for toxicity to *C. dubia*, mortality was observed in one sample and reproductive toxicity was observed in the other sample. Mortality to *H. azteca* was observed in two of six bulk sediment samples (33%) and five of six (80%) porewater samples. Significant growth reduction in *H. azteca* was observed in one of three samples (33%).

Through the TMDL Work Plan, two TIEs were conducted on porewater extracted from bulk sediment toxic to *H. azteca*. In the first TIE conducted, chlorpyrifos was identified as a potential toxicant in the porewater, based on the TIEs and porewater chemistry. Chlorpyrifos in porewater was measured at 0.067 ug/L, above the low range of published LC_{50} values for *H. azteca* of 0.04-0.14 ug/L. However, the Phase I and Phase II TIE did not conclude that chlorpyrifos was the only cause of toxicity. The potential exists that another organic compound was contributing to toxicity. In addition to the detection of chlorpyrifos in porewater, total ammonia (0.58 mg/L) and the triazine herbicide prometryn (0.003 ug/L) were detected. Studies have indicated that the triazine herbicide atrazine can have synergistic effects that potentiate (increase) the toxicity of chlorpyrifos (Lindstrom and Lydy, 1997; Belden and Lydy, 2000; Anderson and Lydy, 2002; Clark *et al.*, 2002). The results of these same studies suggest the potential for similar interactions to occur between prometryn and chlorpyrifos. Synergistic effects on toxicity (also described as potentiating toxicity) are considered to exist when the total effect of the combination of constituents are greater than the sum of the individual effects. However, the concentrations at which prometryn were detected in this sample are 3000 times lower than the concentrations of atrazine at which synergistic effects were observed in the cited studies. Although ammonia toxicity has been shown to be additive to OP pesticide toxicity (Bailey et al., 2001), total ammonia levels measured in porewater (0.58 mg/L) were well below the 96-hr acute LC50 values of 14.2-19.8 mg/L total ammonia (Whiteman, 1996 and Ankley et al. 1995). Chlorpyrifos was not detected in the bulk sediment at a detection limit of 0.005 ug/g.

The second TIE conducted on porewater identified ammonia as a potential toxicant to *H. azteca* based on the TIE and porewater chemistry data. Ammonia in porewater was measured at 20 mg/L, above the 96-hr acute LC50 values of 14.2-19.8 mg/L total ammonia (Whiteman, 1996 and Ankley et al. 1995). In addition, the addition of PBO increased toxicity suggesting that a compound detoxified through the test species' metabolism was present at sub-lethal levels.

Based on the available information, chlorpyrifos and ammonia have been identified as contributing to sediment toxicity in this reach. Porewater data indicates the presence of the triazine herbicide prometryn, which may potentiate toxicity caused by chlorpyrifos, although these herbicides were detected at concentrations that were orders of magnitude lower than levels identified as potentiating toxicity in available studies. TIEs do not suggest toxicity is being potentiated by or solely caused by prometryn. It has not been demonstrated that potentiation occurs at the relatively low concentrations observed. In addition, porewater data indicate the presence of ammonia which could increase toxicity due to additive effects or solely cause toxicity.

Table 16. Summary Statistics for Relevant Sediment Quality Data for Reach 3

Constituent	N	% Detected	Number Detected	Units	Range of Detection Limits	Mean	Standard Deviation	Median	Maximum Detected Value
Ammonia in Porewater	2	100%	2	mg/L	0.01	NA	NA	NA	20
Prometryn Porewater	2	50%	1	ug/L	0.001	NA	NA	NA	0.003
Chlorpyrifos in Porewater	1	100%	1	ug/L	0.001	NA	NA	NA	0.067
Chlorpyrifos in Bulk Sediment	6	17%	1	ug/g	0.001-0.01	NA	NA	NA	0.005

NA Insufficient data to develop summary statistics

Reach: Calleguas Creek Reach 4 (Revolon Slough)

Revolon Slough is on the 2002 303(d) list for water toxicity and chlorpyrifos in fish tissue. As presented in the Problem Statement section, this TMDL will focus on addressing chlorpyrifos in water as opposed to fish tissue. Studies have indicated the presence of chlorpyrifos and diazinon in water and sediment toxicity to various test organisms in samples collected in this reach (UC Davis, CCCS, TMDL Work Plan and

VCWPD). Table 17 presents relevant summary statistics for water quality data. The following is a discussion of current conditions as they relate to the presence of water and sediment toxicity and chlorpyrifos and diazinon in water.

Water Toxicity

Studies conducted through four programs (UC Davis, VCWPD, CCCS, and TMDL Work Plan) have analyzed water samples for toxicity in this reach. A total of 30 samples have been analyzed for toxicity to *C. dubia*, one sample has been analyzed for toxicity to *M. beryllina*, 10 samples have been analyzed for toxicity to *Americamysis bahia*, 12 samples have been analyzed for toxicity to *P. promelas*, and 13 samples have been analyzed for toxicity to *Selenastrum capricornutum*. *C. dubia* mortality was observed in 16 of 39 samples (53%) and reproductive toxicity was observed in three of 13 samples (23%). Mortality was observed in four of 10 samples (40%) and growth toxicity was observed in two of seven samples (29%) tested with *A. bahia*. Mortality to *M. beryllina* was not observed. Mortality to *P. promelas* was observed in four of 12 (33%) and growth toxicity was observed in six of eight (75%) samples. Growth toxicity to *S. capricornutum* was observed in 12 samples (92%).

A total of 10 TIEs have been conducted in this reach through the VCWPD (2), the UC Davis study (5), and the TMDL Work Plan (3). The TIEs conducted by the VCWPD found the primary causes of mortality of *C. dubia* to be metabolically-activated organophosphate compounds and non-polar organic compounds. These TIEs also suggested volatile compounds were possibly contributing to toxicity. The TIE results and the associated water quality data for these samples indicate that chlorpyrifos and diazinon were probably contributing to mortality of *C. dubia*. In both instances chlorpyrifos and diazinon were measured above published LC_{50} values of 0.06-0.09 ug/L and 0.11 ug/L, respectively. In one sample 4-4 DDT was measured at 0.155 ug/L. Although no published 4-4 DDT LC_{50} for *C. dubia* could be located, 4-4 DDT LC_{50} values for *Daphnia magna*, a similar species, presented in the USEPA DDT water quality criteria document (1980) range from 1.48 – 4 ug/L, suggesting DDT was not likely the cause of toxicity in this sample. *C. dubia* are closely related and morphologically similar to *Daphnia* (USEPA, 2002a). The acute sensitivity of *C. dubia* has been compared to *D. magna* under similar test conditions and in most cases *C. dubia* was more sensitive (Mount and Norberg 1984).

All five of the UC Davis study TIEs also indicated toxicity to *C. dubia* was due to metabolically-activated pesticides. Concentrations of chlorpyrifos in four of the samples (0.06, 0.09, 0.92, 0.11 ug/L) met or exceeded the 96-hr LC_{50} for *C. dubia* (0.06-0.09 ug/L). Chlorpyrifos was not detected in one sample at a detection limit of 0.044 ug/L. Concentrations of diazinon in one sample (0.20 ug/L) exceeded the 7-day LC_{50} for *C. dubia* (0.11 ug/L). Diazinon was detected in one other sample (0.03) below the 7-day LC_{50} and was not detected in the remaining three samples at detection limits below 0.04 ug/L. Carbaryl, which unlike chlorpyrifos and diazinon does not need metabolic activation for effectiveness, was detected in three of the five samples, but concentrations were significantly lower than the reported LC_{50} (11.6 ug/L). TIE manipulation of *S. capricornutum* samples did not result in reduction of toxicity, and the results indicate that *S. capricornutum* toxicity was not caused by chlorine or non-polar organic compounds.

Three TIEs were conducted through the TMDL Work Plan. The first TIE was initiated on the sample immediately after it was received by the laboratory in an attempt to characterize degrading toxicity observed in the previous sample collected in this reach. No mortality or growth toxicity to *C. dubia* were observed in this sample. However, in the TIE sample treated with PBO, significant mortality and growth toxicity were observed. PBO is used to inhibit the metabolism of a test species to eliminate toxicity related to metabolically activated compounds such as diazinon and chlorpyrifos. The presence of toxicity in the

PBO treated sample suggests that a compound detoxified through the test species' metabolism was present at sub-lethal levels.

Results of the second TIE conducted on the one storm water toxicity sample collected in this reach through the TMDL Work Plan suggest that one or more OP pesticides are likely responsible for the observed toxicity. Water chemistry indicates the presence of chlorpyrifos (0.119 ug/L) above published LC_{50} values of 0.06-0.09 ug/L and diazinon (0.023 ug/L) well below the 7-day LC_{50} value of 0.11 ug/L. Additionally, the triazine herbicides prometryn (0.121 ug/L) and simazine (0.559 ug/L) were detected and may potentiate chlorpyrifos toxicity based on research indicating a synergistic relationship between chlorpyrifos and the triazine herbicide atrazine (Lindstrom and Lydy, 1997; Belden and Lydy, 2000; Anderson and Lydy, 2002; Clark *et al.*, 2002). However, the concentrations at which prometryn and simazine were detected in this sample are 83 and 18 times lower, respectively, than the concentrations of atrazine at which synergistic effects were observed in the cited studies.

Results of the final TIE conducted through the TMDL Work Plan identified chlorpyrifos as contributing to toxicity. Chlorpyrifos was measured in the sample at 0.135 ug/L, above published LC_{50} values of 0.06-0.09 ug/L. Additionally, the triazine herbicide prometryn was detected at 0.116 ug/L and may potentiate chlorpyrifos toxicity based on research indicating a synergistic relationship between chlorpyrifos and the triazine herbicide atrazine (Lindstrom and Lydy, 1997; Belden and Lydy, 2000; Anderson and Lydy, 2002; Clark *et al.*, 2002). However, the concentrations at which prometryn were detected in this sample are 86 times lower than the concentrations of atrazine at which synergistic effects were observed in the cited studies.

Based on the available information, chlorpyrifos has been identified as contributing to water toxicity in this reach. Water chemistry data indicates the presence of triazine herbicides prometryn and simazine, which may potentiate toxicity caused by chlorpyrifos, although these herbicides were detected at concentrations that are an order of magnitude lower than levels identified as potentiating toxicity in available studies. TIEs do not suggest toxicity is being potentiated by or solely caused by these herbicides. It has not been demonstrated that potentiation occurs at the relatively low concentrations observed.

Table 17. Summary Statistics for Relevant Water Quality Data in Reach 4

Constituent	n	% Detected	Number Detected	Range of Detection Limits	Units	Mean	Standard Deviation	Median	Maximum Detected Value	% Above Criteria[1,2]
Atrazine	10	0%	0	0.005-0.047	ug/L	ND	ND	ND	ND	NC
Prometon	4	0%	0	0.005	ug/L	ND	ND	ND	ND	NC
Prometryn	2	100%	2	0.005	ug/L	NA	NA	NA	0.121	NC
Simazine	12	33%	4	0.005-0.06	ug/L	1.17	3.73	0.013	13.0	NC
Simetryn	3	0%	0	0.005	ug/L	ND	ND	ND	ND	NC
Chlorpyrifos	38	55%	21	0.005-2.0	ug/L	0.181	0.296	0.056	1.46	53%
Diazinon	38	47%	18	0.005-2.0	ug/L	0.121	0.218	0.040	1.2	29%

1 % Above Criteria is calculated using only detected values that exceeded the criteria. These values could be higher because not all samples were tested at detection limits below numeric targets.
2 Criteria used: Chlorpyrifos CDFG chronic (0.014 ug/L) Diazinon: USEPA chronic and acute (0.10 ug/L)
NA Insufficient detected data to develop some summary statistics
NC No criteria for these constituents
ND No detected data

Sediment Toxicity
Studies conducted through two programs (CCCS and TMDL Work Plan) have analyzed sediment samples for toxicity in this reach. A total of five bulk sediment samples have been analyzed for toxicity to *H. azteca*. Mortality to *H. azteca* was observed in three of five samples (60%) and growth toxicity was observed in one of three samples (33%). Two porewater samples have been analyzed for toxicity to *H. azteca* with mortality observed in both samples. Two porewater samples have been analyzed for toxicity to *C. dubia* with no mortality or reproductive toxicity observed in the samples.

Three TIEs have been conducted in this reach through the TMDL Work Plan. In the first TIE conducted on porewater from a sediment sample collected in this reach chlorpyrifos was identified as a potential toxicant to *H. azteca* based on the TIE and porewater chemistry. Analysis of sediment porewater measured chlorpyrifos at 0.933 ug/L, well above the reported 96-hr LC_{50} for *H. azteca* survival (0.04-0.14 ug/L), and the total ammonia concentration measured in porewater (18.3 mg/L), was within the range of the 96-hr acute LC_{50} values of 14.2-19.8 mg/L total ammonia (Whiteman, 1996 and Ankley et al. 1995). The TIE and porewater chemistry results suggest co-occurring ammonia and chlorpyrifos toxicity. Additionally, the triazine herbicide prometryn was detected at 0.048 ug/L and may potentiate chlorpyrifos toxicity based on research indicating the herbicide atrazine can have synergistic effects that potentiate (increase) the toxicity of chlorpyrifos (Lindstrom and Lydy, 1997; Belden and Lydy, 2000; Anderson and Lydy, 2002; Clark *et al.*, 2002). However, the concentrations at which prometryn were detected in this sample are 200 times lower than the concentrations of atrazine at which synergistic effects were observed in the cited studies. Ammonia toxicity has been shown to be additive to OP pesticide toxicity (Bailey *et al.*, 2001). In this sample, chlorpyrifos was detected in the bulk sediment at 0.0458 ug/g.

In the second TIE conducted on porewater, results suggested that ammonia and one or more organic compounds contributed to toxicity to *H. azteca*. The total ammonia concentration measured in porewater (16.2 mg/L) was within the range of the 96-hr acute LC_{50} values of 14.2-19.8 mg/L total ammonia (Whiteman, 1996 and Ankley et al. 1995). In addition, the chlorpyrifos concentration measured in porewater (0.251 ug/L) was above the reported 96-hr LC_{50} for *H. azteca* survival (0.04-0.14 ug/L). These results indicated the potential for co-occurring additive ammonia and chlorpyrifos toxicity. The triazine herbicide prometryn was also detected, but the analytical laboratory was not able to quantify the concentration. As mentioned previously, studies have indicated that the triazine herbicide atrazine can potentiate chlorpyrifos toxicity (Lindstrom and Lydy, 1997; Belden and Lydy, 2000; Anderson and Lydy, 2002; Clark *et al.*, 2002), suggesting the potential for similar interactions to occur between prometryn and chlorpyrifos. Ammonia toxicity has been shown to be additive to OP pesticide toxicity (Bailey *et al.*, 2001). In this sample, chlorpyrifos was not detected in the bulk sediment at a detection limit of 0.007 ug/g.

In the final TIE conducted on porewater, results suggested that ammonia and one or more organic compounds contributed to toxicity to *H. azteca*. The total ammonia concentration measured in porewater (22 mg/L) was above the 96-hr acute LC_{50} values of 14.2-19.8 mg/L total ammonia (Whiteman, 1996 and Ankley et al. 1995). In addition, the chlorpyrifos concentration measured in porewater (0.108 ug/L) was within the range of the reported 96-hr LC_{50} for *H. azteca* survival (0.04-0.14 ug/L). These results indicated the potential for co-occurring additive ammonia and chlorpyrifos toxicity. Additionally, the triazine herbicide prometryn was detected at 0.198 ug/L and may potentiate chlorpyrifos toxicity based on research indicating the herbicide atrazine can have synergistic effects that potentiate (increase) the toxicity of chlorpyrifos (Lindstrom and Lydy, 1997; Belden and Lydy, 2000; Anderson and Lydy, 2002; Clark *et al.*, 2002). However, the concentrations at which prometryn were detected in this sample are 50 times lower than the concentrations of atrazine at which synergistic effects were observed in the cited studies. Ammonia toxicity has been shown to be additive to OP pesticide toxicity (Bailey *et al.*, 2001). In this sample, chlorpyrifos was detected in the bulk sediment at 0.006 ug/g.

Based on the available information, chlorpyrifos and ammonia have been identified as contributing to sediment toxicity in this reach. Porewater chemistry data indicates the presence of triazine herbicide prometryn, which may potentiate toxicity caused by chlorpyrifos, although these herbicides were detected at concentrations that were at least an order of magnitude lower than levels identified as potentiating toxicity in available studies. Furthermore, it has not been demonstrated that potentiation occurs at the relatively low concentrations observed. TIEs do not suggest toxicity is being potentiated by or solely caused by prometryn.

Table 18. Summary Statistics for Relevant Sediment Quality Data in Reach 4

Constituent	n	% Detected	Number Detected	Units	Range of Detection Limits	Mean	Standard Deviation	Median	Maximum Detected Value
Ammonia Porewater	3	100%	3	mg/L	0.01	18.8	2.94	18.7	18.3
Prometryn Porewater	3	100%	3	ug/L	0.001	NA	NA	NA	0.198
Chlorpyrifos Porewater	2	100%	2	ug/L	0.001	0.430	0.441	0.294	0.933
Chlorpyrifos in Bulk Sediment	11	73%	8	ug/g	0.001-0.007	0.011	0.012	0.008	0.17

NA Insufficient data to develop summary statistics

<u>Reach: Calleguas Creek Reach 5 (Beardsley Channel)</u>

Beardsley Channel is on the 2002 303(d) list for water toxicity and chlorpyrifos in fish tissue. As discussed in the Problem Statement section, this TMDL will focus on addressing chlorpyrifos in water as opposed to fish tissue. Additional studies have indicated the presence of chlorpyrifos and diazinon in water. Table 19 presents summary statistics for relevant water quality data. The following is a discussion of current conditions as they relate to the presence of water toxicity and chlorpyrifos and diazinon in water.

Water Toxicity

Studies conducted through the UC Davis Study and the TMDL Work Plan have analyzed water samples for toxicity in this reach. A total of eight samples have been analyzed for toxicity to *C. dubia* and nine samples have been analyzed for toxicity to *A. bahia*. *C. dubia* mortality was observed in three of eight samples (38%) and reproductive toxicity was observed in none of the five samples tested. *A. bahia* mortality was observed in two samples (22%) and growth toxicity was observed in three samples (33%).

Two TIEs have been conducted in this reach through the UC Davis study. Both TIEs indicated chlorpyrifos as the cause of mortality of *C. dubia*. The concentrations of chlorpyrifos in each sample (0.177 and 0.149 ug/L) exceeded the 96-hr LC_{50} for *C. dubia* (0.06-0.09 ug/L). Recent water toxicity testing through the TMDL Work Plan observed intermittent acute and chronic toxicity to test species. However, none of these samples were above the established trigger level (>50% mortality) for TIE initiation.

Although more recent water toxicity testing through the TMDL Work Plan has not determined a toxicant, based on the UC Davis Study, chlorpyrifos has been identified as contributing to water toxicity in this reach. Chlorpyrifos has been detected during sampling conducted through the TMDL Work Plan monitoring program. As discussed previously, triazine herbicides may potentiate chlorpyrifos toxicity. Triazine herbicides have been detected in this reach; however, TIEs conducted in this reach have not suggested that triazine herbicides are potentiating chlorpyrifos toxicity. Water quality summary statistics for these constituents are provided along with diazinon and chlorpyrifos information in Table 19.

Table 19. Summary Statistics for Relevant Water Quality Data in Reach 5

Constituent	n	% Detected	Number Detected	Units	Range of Detection Limits	Mean	Standard Deviation	Median	Maximum Detected Value	% Above Criteria[1,2]
Atrazine	12	0%	0	ug/L	0.005-0.047	ND	ND	ND	ND	NC
Prometon	6	0%	0	ug/L	0.005	ND	ND	ND	ND	NC
Prometryn	4	100%	4	ug/L	0.005	0.035	0.025	0.029	0.07	NC
Simazine	12	25%	3	ug/L	0.005-0.06	0.567	0.706	0.292	2.07	NC
Simetryn	6	0.0%	0	ug/L	0.005	ND	ND	ND	ND	NC
Chlorpyrifos	16	75%	12	ug/L	0.005-0.044	0.061	0.051	0.042	0.177	75%
Diazinon	16	13%	2	ug/L	0.005-0.038	NA	NA	NA	0.317	6%

1 % Above Criteria is calculated using only detected values that exceeded the criteria. These values could be higher because not all samples were tested at detection limits below numeric targets.
2 Criteria used: Chlorpyrifos CDFG chronic (0.014 ug/L)   Diazinon: USEPA chronic and acute (0.10 ug/L).
NA Insufficient detected data to develop some summary statistics
NC No criteria for these constituents
ND No detected data

Reach: Calleguas Creek Reach 6 (Arroyo Las Posas)

Arroyo Las Posas is not on the 2002 303(d) list for water or sediment toxicity. However, the CCCS and the TMDL Work Plan identified occurrences of water and sediment toxicity to various test organisms in samples collected in this reach. In addition, water quality data have indicated the presence of chlorpyrifos and diazinon. Table 20 presents summary statistics for relevant water quality data. The following is a discussion of current conditions as they relate to the presence of water and sediment toxicity and chlorpyrifos and diazinon in water.

Water Toxicity

Studies conducted through two programs (CCCS and TMDL Work Plan) have analyzed water samples for toxicity in this reach. A total of 14 samples have been analyzed for toxicity to *C. dubia* and six samples have been analyzed for toxicity to *P. promelas*. *C. dubia* mortality was observed in three samples (21%) and reproductive toxicity was observed in nine samples (64%). Mortality and growth toxicity to *P. promelas* was not observed.

In the one TIE conducted in this reach through the TMDL Work Plan, diazinon was identified as causing mortality. Diazinon was measured at 0.289 ug/L, exceeding the 7-day LC_{50} value of 0.11 ug/L for *C. dubia*. Additionally, the triazine herbicides simazine (0.028 ug/L) and atrazine (0.011 ug/L) were detected and may potentiate diazinon toxicity based on research indicating a synergistic relationship between diazinon and the triazine herbicide atrazine (Belden and Lydy, 2000; Anderson and Lydy, 2002). The results of these same studies suggest the potential for similar interactions to occur between simazine and diazinon. However, the concentrations at which simazine and atrazine were detected in this sample are 300 and 900 times lower, respectively, than the concentrations of atrazine at which synergistic effects were observed in the cited studies.

Based on the available information diazinon has been identified as contributing to water toxicity in this reach. Water chemistry data indicates the presence of the triazine herbicides simazine and atrazine, which may potentiate toxicity caused by chlorpyrifos, although these herbicides were detected at concentrations that were orders of magnitude lower than levels identified as potentiating toxicity in available studies. It has not been demonstrated that potentiation occurs at the relatively low concentrations observed. TIEs do not suggest toxicity is being potentiated by or solely caused by these herbicides.

Table 20. Summary Statistics for Relevant Water Quality Data in Reach 6

Constituent	n	% Detected	Number Detected	Units	Range of Detection Limits	Mean	Standard Deviation	Median	Maximum Detected Value	% Above Criteria[1,2]
Ammonia as N	9	90%	8	mg/L	0.01	0.572	0.792	0.127	2.20	0%
Atrazine	6	83%	5	ug/L	0.005	0.014	0.004	0.013	0.019	NC
Prometon	6	33%	2	ug/L	0.005	NA	NA	NA	0.011	NC
Prometryn	4	0%	0	ug/L	0.005	ND	ND	ND	ND	NC
Simazine	6	50%	3	ug/L	0.005	0.028	0.01	0.026	0.04	NC
Simetryn	6	0%	0	ug/L	0.005	ND	ND	ND	ND	NC
Chlorpyrifos	10	30%	3	ug/L	0.005	0.013	0.028	0.001	0.087	20%
Diazinon	10	60%	6	ug/L	0.005	0.057	0.086	0.024	0.289	10%

1 % Above Criteria is calculated using only detected values that exceeded the criteria.
2 Criteria used: Chlorpyrifos CDFG chronic (0.014 ug/L) Diazinon: USEPA chronic and acute (0.10 ug/L) Ammonia: CCW Nutrients TMDL chronic (2.63 mg/L).
NA Insufficient detected data to develop some summary statistics
NC No criteria for these constituents
ND No detected data

Sediment Toxicity

Studies conducted through two programs (CCCS and TMDL Work Plan) have analyzed sediment samples for toxicity in this reach. A total of five bulk sediment samples have been analyzed for toxicity to *H. azteca*. Mortality to *H. azteca* was observed in one sample (20%) and growth toxicity was not observed. Two samples have been analyzed for porewater toxicity to *C. dubia,* mortality was not observed in either sample. Sediment toxicity was observed in this reach during one sampling event conducted through the CCCS in November 1998. However, during the more recent TMDL Work Plan monitoring (August 2003 through April 2004) no toxicity was observed in sediment. No TIEs have been conducted in this reach. Based on the available information sediment toxicity in this reach is either intermittent or there is not an impairment in this reach. This reach is not on the 303(d) list for sediment toxicity.

Reach: Calleguas Creek Reach 7 (Arroyo Simi)

The Arroyo Simi is listed for organophosphate pesticides in water; however, as presented in the Problem Statement section, chlorpyrifos and diazinon were identified as the two OP pesticides contributing to the impairment in this reach. Additionally, studies have identified occurrences of water and sediment toxicity to various test organisms in samples collected in this reach. Table 21 presents summary statistics for relevant water quality data. The following is a discussion of current conditions as they relate to the presence of chlorpyrifos and diazinon in water and water and sediment toxicity in this reach.

Water Toxicity

Studies conducted through three programs (UC Davis, CCCS, and TMDL Work Plan) have analyzed water samples for toxicity in this reach. A total of 32 samples have been analyzed for toxicity to *C. dubia* and 22 samples have been analyzed for toxicity to *P. promelas*. *C. dubia* mortality was observed in 11 of 32 samples (34%) and reproductive toxicity was observed in 20 of 27 samples (74%). Mortality to *P. promelas* was observed in 14 of 22 (64%) and growth toxicity was observed in six of 18 (33%) samples.

A total of seven TIEs have been conducted in this reach through the UC Davis study (3), the CCCS (3) and the TMDL Work Plan (1). The three TIEs conducted in the UC Davis study suggest diazinon was the cause of toxicity. The concentrations of diazinon in each sample (0.410, 0.400, and 0.430 ug/L) exceeded the 7-day LC_{50} for *C. dubia* (0.11 ug/L). Chlorpyrifos was not detected in any of these samples. Manipulation of pH in five *P. promelas* samples collected downstream of the SVWQCP resulted in a reduction of toxicity. Unionized ammonia concentrations in these samples ranged from 2.39-4.76 mg/L exceeding the reported LC_{50} of 0.6-1.0 mg/L. This suggests ammonia was a cause of mortality of *P. promelas*.

In two of the TIEs conducted for the CCCS, the observed toxicity was no longer present in the ambient sample at completion of the TIE making the results inconclusive. For the remaining TIE, ammonia was identified as a toxicant. Although removal of ammonia reduced toxicity, the overall toxicity remained significant, suggesting additional constituents are contributing to observed toxicity.

In the one TIE conducted in this reach through the TMDL Work Plan, diazinon was identified as causing toxicity. Diazinon was measured at 0.379 ug/L, well above the 7-day LC_{50} value for *C. dubia* of 0.11 ug/L. Additionally, the triazine herbicide simazine (0.021 ug/L) was detected and may potentiate diazinon toxicity based on research indicating a synergistic relationship between diazinon and the triazine herbicide atrazine (Belden and Lydy, 2000; Anderson and Lydy, 2002). However, the concentration at which simazine was detected in this sample is 475 times lower than the concentrations of atrazine at which synergistic effects were observed in the cited studies.

Based on the available information diazinon and ammonia have been identified as contributing to water toxicity in this reach. Water chemistry data indicates the presence of the triazine herbicide simazine, which may potentiate toxicity caused by diazinon, although this herbicides were detected at concentrations that were orders of magnitude lower than levels identified as potentiating toxicity in available studies. It has not been demonstrated that potentiation occurs at the relatively low concentrations observed. Water chemistry data indicate the presence of ammonia which could increase toxicity due to additive effects. TIEs do not suggest toxicity is being potentiated by or solely caused by simazine.

Table 21. Summary Statistics for Relevant Water Quality Data in Reach 7

Constituent	n	% Detected	Number Detected	Units	Range of Detection Limits	Mean	Standard Deviation	Median	Maximum Detected Value	% Above Criteria[1,2]
Ammonia as N	10	100%	10	mg/L	0.01	5.17	5.35	2.32	17.00	50%
Atrazine	3	100%	3	ug/L	0.005	0.014	0.005	0.014	0.018	NC
Prometon	6	17%	1	ug/L	0.005-0.1	NA	NA	NA	0.014	NC
Prometryn	1	0%	0	ug/L	0.005	ND	ND	ND	ND	NC
Simazine	6	33%	2	ug/L	0.005-0.5	NA	NA	NA	0.031	NC
Simetryn	3	0%	0	ug/L	0.005	ND	ND	ND	ND	NC
Chlorpyrifos	23	17%	4	ug/L	0.005-0.05	NA	NA	0.038[3]	0.361	13%
Diazinon	26	69%	18	ug/L	0.005-0.05	0.122	0.150	0.056	0.451	27%

1 % Above Criteria is calculated using only detected values that exceeded the criteria. These values could be higher because not all samples were tested at detection limits below numeric targets.
2 Criteria used: Chlorpyrifos CDFG chronic (0.014 ug/L) Diazinon: USEPA chronic and acute (0.10 ug/L) Ammonia: CCW Nutrients TMDL chronic (2.35 mg/L).
3 Developed using detected data only.
NA Insufficient detected data to develop some summary statistics
NC No criteria for these constituents
ND No detected data

Although the listing for this reach is “Organophosphate Pesticides”, numeric targets will be set for chlorpyrifos and diazinon to address this listing as diazinon has been identified as an OP pesticide contributing to toxicity and both have been observed to exceed water quality criteria.

Sediment Toxicity

Studies conducted through two programs (CCCS and TMDL Work Plan) have analyzed sediment samples for toxicity in this reach. Five bulk sediment samples have been analyzed for toxicity to *H. azteca*. Mortality to *H. azteca* was observed in one of five samples (20%) and growth toxicity was observed in one of three samples (33%). Two porewater samples have been analyzed for toxicity to *C. dubia* with no mortality or reproductive toxicity observed in the samples. The only observed sediment toxicity in this reach occurred during one sampling event conducted through the CCCS in November 1998. However, during the more recent TMDL Work Plan monitoring (August 2003 through April 2004) no toxicity was observed in sediment. No TIEs have been conducted in this reach. Based on the available information sediment toxicity in this reach is either intermittent or there is not an impairment in this reach. This reach is not listed on the 303(d) list for sediment toxicity.

Reach: Calleguas Creek Reach 8 (Tapo Canyon)

Tapo Canyon is not listed on the 2002 303(d) list for toxicity. However, water quality data have indicated the presence of chlorpyrifos and diazinon (Table 22).

Table 22. Summary Statistics for Relevant Water Quality Data in Reach 8

Constituent	N	% Detected	Number Detected	Units	Range of Detection Limits	Mean	Standard Deviation	Median	Maximum Detected Value	% Above Criteria[1,2]
Chlorpyrifos	16	6%	1	ug/L	0.005-0.05	NA	NA	NA	0.080	6%
Diazinon	16	19%	3	ug/L	0.005-0.05	NA	NA	0.2[3]	0.550	19%

1 % Above Criteria is calculated using only detected values that exceeded the criteria. These values could be higher because not all samples were tested at detection limits below numeric targets.
2 Criteria used: Chlorpyrifos CDFG chronic (0.014 ug/L) Diazinon: USEPA chronic and acute (0.10 ug/L).
3 Developed using detected data only.
NA Insufficient detected data to develop some summary statistics

Reach: Calleguas Creek Reach 9A (Conejo Creek)

Conejo Creek is not listed on the 2002 303(d) list for water or sediment toxicity. However, studies have identified occurrences of water and sediment toxicity to various test organisms in samples collected in this reach (CCCS and TMDL Work Plan). In addition, water quality data have indicated the presence of chlorpyrifos and diazinon. Table 23 presents summary statistics for relevant water quality data. The following is a discussion of current conditions as they relate to the presence of water and sediment toxicity and chlorpyrifos and diazinon in water.

Water Toxicity

Studies conducted through two programs (CCCS and TMDL Work Plan) have analyzed water samples for toxicity in this reach. A total of 16 samples have been analyzed for toxicity to *C. dubia* and six samples have been analyzed for toxicity to *P. promelas*. *C. dubia* mortality was observed in three samples (19%) and reproductive toxicity was observed in seven samples (44%). Mortality to *P. promelas* was not observed, however, growth toxicity was observed in two samples (33%).

A total of three TIEs have been conducted in this reach through the TMDL Work Plan. In the first TIE, toxicity degraded during the Phase I TIE and results were inconclusive. Results of the TIE conducted on the one storm water toxicity sample collected in this reach through the TMDL Work Plan suggest that one or more OP pesticides are likely responsible for the observed toxicity. Water chemistry measured diazinon at 0.233 ug/L exceeding the 7-day LC_{50} value of 0.11 ug/L. The OP pesticide dimethoate was measured at 0.508 ug/L; however, there are no readily available dimethoate toxicity data with respect to *C. dubia*. Pacific EcoRisk, the toxicity testing laboratory contracted for the TMDL Work Plan, found that dimethoate concentrations as high as 1.46 ug/L would not be expected to impair *C. dubia* survival or reproduction, indicating that dimethoate was not causing the observed toxicity. The triazine herbicides prometryn (0.235 ug/L) and simazine (0.28 ug/L) were detected and may potentiate diazinon toxicity based on research indicating a synergistic relationship between diazinon and the triazine herbicide atrazine (Belden and Lydy, 2000; Anderson and Lydy, 2002). However, the concentrations at which prometryn and simazine were detected in this sample are 40 and 35 times lower, respectively, than the concentrations of atrazine at which synergistic effects were observed in the cited studies. Results of the final TIE conducted through the TMDL Work Plan were inconclusive as toxicity degraded during the Phase I TIE. However, diazinon was measured at 0.213 ug/L, exceeding the 7-day LC_{50} value of 0.11 ug/L.

Based on the available information, diazinon has been identified as contributing to water toxicity in this reach. Water chemistry data indicates the presence of the triazine herbicides prometryn and simazine, although these herbicides were detected at concentrations that were orders of magnitude lower than levels identified as potentiating toxicity in available studies. It has not been demonstrated that potentiation occurs at the relatively low concentrations observed. TIEs do not suggest toxicity is being potentiated by or solely caused by these herbicides.

Table 23. Summary Statistics for Relevant Water Quality Data in Reach 9A

Constituent	n	% Detected	Number Detected	Units	Range of Detection Limits	Mean	Standard Deviation	Median	Maximum Detected Value	% Above Criteria[1,2]
Atrazine	3	0%	0	ug/L	0.005	ND	ND	ND	ND	NC
Prometon	4	0%	0	ug/L	0.005-0.1	ND	ND	ND	ND	NC
Prometryn	1	100%	1	ug/L	0.005	NA	NA	NA	0.235	NC
Simazine	4	75%	3	ug/L	0.005-0.5	0.089	0.128	0.042	0.280	NC
Simetryn	3	0%	0	ug/L	0.005	ND	ND	ND	ND	NC
Chlorpyrifos	15	0%	0	ug/L	0.005-0.05	ND	ND	ND	ND	0%
Diazinon	15	53%	8	ug/L	0.005-0.05	0.089	0.110	0.035	0.354	33%

1 % Above Criteria is calculated using only detected values that exceeded the criteria. These values could be higher because not all samples were tested at detection limits below numeric targets.
2 Criteria used: Chlorpyrifos CDFG chronic (0.014 ug/L) Diazinon: USEPA chronic and acute (0.10 ug/L).
NA Insufficient detected data to develop some summary statistics
NC No criteria for these constituents
ND No detected data

Sediment Toxicity

Studies conducted through two programs (CCCS and TMDL Work Plan) have analyzed sediment samples for toxicity in this reach. A total of six bulk sediment samples have been analyzed for toxicity to *H. azteca*. Mortality to *H. azteca* was observed in three of six samples (50%) and growth toxicity was observed in two of four samples (50%). Three porewater samples have been analyzed for toxicity to *H. azteca* with mortality observed in all three samples. Two porewater samples have been analyzed for toxicity to *C. dubia* with no mortality or reproductive toxicity observed in the samples.

Two Phase I TIEs were conducted in this reach through the TMDL Work Plan. The first TIE was somewhat inconclusive. The results suggested there are possibly multiple compounds causing toxicity which may or may not include metals, organics, and/or ammonia. Total ammonia levels was measured in the porewater at 3.03 mg/L, below 96hr-hr acute LC_{50} values of 14.2-19.8 mg/L total ammonia (Whiteman, 1996 and Ankley et al. 1995). However, ammonia has shown to cause additive toxicity in the presence of other compounds (i.e., metals and OP pesticides [Bailey *et al.*, 2001]).

In the second TIE conducted on porewater, results suggested organics were one cause of toxicity. Furthermore, the addition of PBO increased toxicity suggesting that a compound detoxified through the test species' metabolism was present at sub-lethal levels. Diazinon was measured in the porewater at 1.05 ug/L below the 10-day LC_{50} of 6.5 ug/L for *H. azteca* but was not identified as a toxicant. The triazine herbicide prometryn was also detected at 0.094 ug/L. In this sample, diazinon was measured in the bulk sediment at a detection limit of 0.007 ug/g. A Phase II TIE conducted on this sample was inconclusive.

Based on the available information, it is not clear what constituent(s) are contributing to sediment toxicity in this reach. However, TIE data suggest the constituent(s) are organic in nature.

Table 24. Summary Statistics for Relevant Sediment Quality Data in Reach 9A

Constituent	n	% Detected	Number Detected	Units	Range of Detection Limits	Mean	Standard Deviation	Median	Maximum Detected Value
Ammonia Porewater	1	100%	1	mg/L	0.01	NA	NA	NA	3.03
Diazinon in Porewater	1	100%	1	ug/L	0.001	NA	NA	NA	1.05
Chlorpyrifos in Bulk Sediment	4	0%	0	ug/g	0.001-0.007	ND	ND	ND	ND
Diazinon in Bulk Sediment	4	0%	1	ug/g	0.005	NA	NA	NA	0.007

NA Insufficient data to develop summary statistics
ND No detected data

Reach: Calleguas Creek Reach 9B (Conejo Creek Main Stem)

The Conejo Creek Main Stem is listed on the 2002 303(d) list for water toxicity. In addition, water quality data have indicated the presence of chlorpyrifos and diazinon. Table 25 presents summary statistics for relevant water quality data. The following is a discussion of current conditions as they relate to the presence of water toxicity and chlorpyrifos and diazinon in water.

Water Toxicity

Studies conducted through two programs (UC Davis and TMDL Work Plan) have analyzed water samples for toxicity in this reach. A total of 17 samples have been analyzed for toxicity to *C. dubia* and eight samples have been analyzed for toxicity to *P. promelas*. *C. dubia* mortality was observed in five of 17 samples (29%) and reproductive toxicity was observed in five of 13 samples (38%). Mortality to *P. promelas* was observed in four samples (50%) and growth toxicity was observed in one sample (13%).

A single Phase I and II TIE test was conducted through the UC Davis study. The results of the TIE testing indicated diazinon was a potential cause of toxicity to *C. dubia*. The concentration of diazinon was measured at 0.230 ug/L, which is well above the 7-day LC_{50} for *C. dubia* (0.11 ug/L). Manipulation of pH in three *P. promelas* samples resulted in a reduction of toxicity. Unionized ammonia concentrations in these samples (2.12, 2.77, and 5.23 mg/L) exceed the reported LC_{50} of 0.6-1.0 mg/L. This suggests that ammonia was a cause of mortality of *P. promelas*.

One TIE analysis was attempted in this reach through the TMDL Work Plan. However, toxicity degraded in the sample during the TIE process resulting in an inconclusive TIE.

Based on the available information diazinon and ammonia are identified as contributing to water toxicity in this reach.

Table 25. Summary Statistics for Relevant Water Quality Data in Reach 9B

Constituent	n	% Detected	Number Detected	Units	Range of Detection Limits	Mean	Standard Deviation	Median	Maximum Detected Value	% Above Criteria[1,2]
Ammonia as N	9	90%	8	ug/L	0.01	0.4	0.8	0.045	2.15	0%
Chlorpyrifos	15	20%	3	ug/L	0.005-0.05	0.011	0.020	0.002	0.06	13%
Diazinon	19	53%	10	ug/L	0.005-0.25	0.064	0.073	0.03	0.23	21%

1 % Above Criteria is calculated using only detected values that exceeded the criteria. These values could be higher because not all samples were tested at detection limits below numeric targets.
2 Criteria used: Chlorpyrifos CDFG chronic (0.014 ug/L) Diazinon: USEPA chronic and acute (0.10 ug/L) Ammonia: CCW Nutrients TMDL chronic (3.36 mg/L)

Reach: Calleguas Creek Reach 10 (Hill Canyon Reach of Conejo Creek)

Hill Canyon is listed on the 2002 303(d) list for water toxicity. Additional studies have indicated the presence of chlorpyrifos and diazinon in water and sediment toxicity to various test organisms in samples collected in this reach (CCCS and TMDL Work Plan). Table 26 presents summary statistics for relevant water quality data. The following is a discussion of current conditions as they relate to the presence of chlorpyrifos and diazinon in water and water and sediment toxicity in this reach.

Water Toxicity

Studies conducted through two programs (CCCS and TMDL Work Plan) have analyzed water samples for toxicity in this reach. A total of 16 samples have been analyzed for toxicity to *C. dubia* and six samples have been analyzed for toxicity to *P. promelas*. *C. dubia* mortality was observed in four of 16 samples (25%) and reproductive toxicity was observed in seven of 15 samples (47%). Mortality to *P. promelas* was observed in three of six (50%) samples and growth toxicity was observed in one of three samples (33%).

Two Phase I TIEs were conducted in this reach through the CCCS. However, toxicity degraded during the TIE process, making TIE results inconclusive. Based on the available information it is not clear what pollutant(s) are contributing to water toxicity in this reach.

Table 26. Summary Statistics for Relevant Water Quality Data in Reach 10

Constituent	n	% Detected	Number Detected	Units	Range of Detection Limits	Mean	Standard Deviation	Median	Maximum Detected Value	% Above Criteria[1,2]
Chlorpyrifos	16	0%	0	ug/L	0.005-0.5	ND	ND	ND	ND	0%
Diazinon	16	38%	6	ug/L	0.005-0.5	0.047	0.029	0.029	0.158	19%

1 % Above Criteria is calculated using only detected values that exceeded the criteria. These values could be higher because not all samples were tested at detection limits below numeric targets.
2 Criteria used: Chlorpyrifos CDFG chronic (0.014 ug/L) Diazinon: USEPA chronic and acute (0.10 ug/L).
NA Insufficient detected data to develop some summary statistics
ND No detected data

Sediment Toxicity

Studies conducted through two programs (CCCS and TMDL Work Plan) have analyzed sediment samples for toxicity in this reach. A total of five samples have been analyzed for toxicity to *H. azteca*. Mortality to *H. azteca* was observed in one sample (20%) and no growth toxicity was observed in three samples. Three porewater samples have been analyzed for toxicity to *H. azteca* with no mortality observed. Two porewater samples have been analyzed for toxicity to *C. dubia* with no mortality or reproductive toxicity observed in the samples. Sediment toxicity was observed in this reach during the CCCS with two sampling events occurring in November 1998 and May 1999. However, during the more recent TMDL Work Plan monitoring (August 2003 through April 2004) no toxicity was observed in sediment. No TIEs have been conducted in this reach. Based on the available information it is not clear if there is a sediment toxicity impairment in this reach. This reach is not listed on the 303(d) list for sediment toxicity.

Reach: Calleguas Creek Reach 11 (Arroyo Santa Rosa)

The Arroyo Santa Rosa is listed on the 2002 303(d) list for water toxicity. However, since the closure of the Olsen Road Water Reclamation Plant in 2002 there is no flow in this reach except during wet weather conditions that cause sufficient runoff to generate flow. Only one sample has been collected in this reach after the closure of the Olsen Road Plant. This sample was collected during wet weather conditions in February 2004 through the TMDL Work Plan monitoring. Reproductive toxicity to *C. dubia* was observed in this sample, but mortality was not observed. No TIEs have been conducted in this reach. Based on the available information it is not clear what pollutant(s) contributed to *C. dubia* reproductive toxicity in this reach during the February 2004 storm event.

Reach: Calleguas Creek Reach 12 (North Fork Conejo Creek)

The North Fork of the Conejo Creek is not listed on the 2002 303(d) list for toxicity. Water quality data have indicated the presence of diazinon (Table 27). However, diazinon was not detected above numeric targets in any of the samples and the reach does not seem to be impaired.

Table 27. Summary Statistics for Relevant Water Quality Data in Reach 12

Constituent	n	% Detected	Number Detected	Units	Mean	Range of Detection Limits	Standard Deviation	Median	Maximum Detected Value	% Above Criteria[1]
Chlorpyrifos	6	0%	0	ug/L	NA	0.005	ND	ND	ND	0%
Diazinon	13	23%	3	ug/L	0.008	0.005-0.03	0.011	0.03[2]	0.035	0%

1 Criteria used: Chlorpyrifos CDFG chronic (0.014 ug/L) Diazinon: USEPA chronic and acute (0.10 ug/L). These values could be higher because not all samples were tested at detection limits below numeric targets.
2 Developed using detected data only.
NA Insufficient detected data to develop some summary statistics
ND No detected data

Reach: Calleguas Creek Reach 13 (South Fork Conejo Creek)

The South Fork of the Conejo Creek is listed on the 2002 303(d) list for water toxicity. In addition, water quality data have indicated the presence of diazinon. Table 28 presents summary statistics for relevant water quality data. The following is a discussion of current conditions as they relate to the presence of diazinon in water and water toxicity in this reach.

Water Toxicity

Studies conducted through the TMDL Work Plan have analyzed nine water samples for toxicity to *C. dubia* in this reach. *C. dubia* mortality was observed in one of nine samples (9%) and reproductive toxicity was observed in six of nine samples (55%). No TIEs have been conducted in this reach. Based on the available information it is not clear what pollutant(s) are contributing to water toxicity in this reach.

Table 28. Summary Statistics for Relevant Water Quality Data in Reach 13

Constituent	n	% Detected	Number Detected	Units	Range of Detection Limits	Mean	Standard Deviation	Median	Maximum Detected Value	% Above Criteria[1,2]
Chlorpyrifos	13	0%	0	ug/L	0.005-0.05	ND	ND	ND	ND	0%
Diazinon	20	40%	8	ug/L	0.005-0.05	0.019	0.018	0.013	0.066	0%

1 % Above Criteria is calculated using only detected values that exceeded the criteria. These values could be higher because not all samples were tested at detection limits below numeric targets.
2 Criteria used: Chlorpyrifos CDFG chronic (0.014 ug/L) Diazinon: USEPA chronic and acute (0.10 ug/L).
NA Insufficient detected data to develop some summary statistics
ND No detected data

3.3 *Additive/Synergistic Toxicity*

Studies of chlorpyrifos and diazinon toxicity conducted by Bailey et al. (1997) "suggests that the two pesticides were additive with respect to acute toxicity." The presence of other constituents can also result in toxicity that is additive or synergistic to the toxicity caused by OP pesticides, such as chlorpyrifos and diazinon. Several of the TIEs conducted on toxic sediment samples indicate that ammonia may be causing additive toxicity in the presence of chlorpyrifos and diazinon. This is consistent with results of a study completed by Bailey et al., in 2001. The data collected through this study "suggest that diazinon and ammonia exhibit somewhat less than additive toxicity when present together in solution."

Two constituents are considered to have a synergistic effect when the effect of the combination of the constituents is greater than the sum of the individual effects. Synergistic effects can potentiate toxicity by causing reactions within organisms that accelerate the processes through which a constituent causes toxicity. For example, OP pesticides inhibit the neurotransmitter enzyme acetylcholinesterase (AChE). Inhibition of AChE causes the accumulation of the neurotransmitter enzyme acetylcholine at the nerve endings. This results in excessive transmission of nerve impulses, thereby causing mortality. Recent research has suggested that in the presence of the triazine herbicides atrazine and cyanazine, the biotransformation efficiency of chlorpyrifos and diazinon is increased (Lindstrom and Lydy, 1997; Belden and Lydy, 2000; Anderson and Lydy, 2002; Clark et al., 2002). This results in higher rates of AChE inhibition and increased chlorpyrifos- and diazinon-associated toxicity. The increased chlorpyrifos- and diazinon-associated toxicity is greater than the sum of the individual effects and is therefore considered to be synergistic.

This research is important to consider as the triazine herbicides atrazine, prometryn, and simazine have been detected in toxic samples where chlorpyrifos and diazinon were identified as toxicants. However, the results of these studies are not directly comparable to conditions in the CCW because 1) the concentrations of atrazine at which synergistic effects were observed in these studies are over 500 times higher than what have been observed in waters in the CCW and 2) the majority of the test species used in these studies are different than the standard test species used to measure toxicity in the CCW. The processes associated with atrazine and cyanazine that cause synergistic effects with OP pesticides may occur with other triazine herbicides or may affect some species at the low concentrations observed in CCW samples. This possibility is suggested in the Current Conditions section. However, it is not possible based on the available information to conclude that triazine herbicides are having an affect on the toxicity of chlorpyrifos and diazinon in the CCW.

The aforementioned research suggests that due to the possibility of additive or potentiated toxicity, achievement of chlorpyrifos and/or diazinon numeric targets may not result in complete removal of toxicity associated with these constituents. However, at this time there is no evidence to suggest that conditions in the CCW warrant an adjustment of numeric targets to consider the possibility of additive or synergistic effects. Future monitoring will continue to test samples for the presence of triazine herbicides and when TIEs are conducted, the potential for synergistic effects will be considered.

3.4 *Water Toxicity Summary*

Table 29 presents a summary of acute and chronic toxicity tests and suspected toxicants by reach. Additionally, exceedances of the diazinon and chlorpyrifos water quality criteria are presented. Chlorpyrifos, diazinon, and ammonia have been identified as constituents causing acute toxicity (mortality) in water in various reaches. The triazine herbicides atrazine, prometryn, and simazine have been detected in toxic samples and have the potential to increase toxicity of OP pesticides. However, these herbicides were not observed to increase toxicity or cause toxicity on their own. A single TIE results suggested non-polar organics contributed to toxicity in one sample; however, water quality data for this sample did not identify this suite of constituents at levels known to be acutely toxic to the test species. In addition, unknown toxicity continues to exist as the toxicant(s) causing toxicity have not been identified in all reaches at all times toxicity was observed.

The information provided in the Current Conditions section identified toxicity in water in the following reaches not on the 2002 303(d) list for toxicity: 3, 6, 7, and 9A. Diazinon and/or chlorpyrifos were observed to exceed criteria in the following reaches not on the 303(d) list for these constituents: 2, 3, 6, 8, 9A, 9B, 10, and 11. In addition to the listings presented in the Problem Statement section, this TMDL will address water toxicity, chlorpyrifos and diazinon in these reaches.

Table 29. Water Toxicity Testing Summary for the CCW

Reach	2002 303(d) Listings	# of acute tests	% with acute toxicity	# of chronic tests	% with chronic toxicity	Suspected Toxicant(s) identified through TIEs	Chlorpyrifos above criteria[2]	Diazinon above criteria[2]
2	NL	NT	NT	NT	NT	NT	Y	Y
3	NL	44	20%	36	22%	Inconclusive	Y	Y
4	T, FT	53	45%	42	55%	Chlorpyrifos[1]	Y	Y
5	T, FT	17	29%	14	21%	Chlorpyrifos	Y	Y
6	NL	20	15%	20	45%	Diazinon[1]	Y	Y
7	OP	54	46%	45	58%	Diazinon[1]	Y	Y
8	NL	NT	NT	NT	NT	NT	Y	Y
9A	NL	22	14%	22	41%	Diazinon[1]	N	Y
9B	T	25	36%	21	29%	Diazinon and Ammonia	Y	Y
10	T	22	32%	18	44%	Inconclusive	N	Y
11	T	1	0%	1	100%	No TIEs conducted	ND	ND
12	NL	NT	NT	NT	NT	NT	N	N
13	T	9	11%	9	67%	No TIEs conducted	N	N

T Listed for water column toxicity FT Listed for chlorpyrifos in fish tissue OP Listed for organophosphate pesticides
NL Not listed for water column toxicity, chlorpyrifos in fish tissue, or organophosphate pesticides.
NT Toxicity testing was not conducted in this reach.
ND Not detected in the one sample collected during storm conditions on February 25, 2004.
1 TIE data suggests water toxicity caused by chlorpyrifos or diazinon may be potentiated, but not solely caused, by triazine herbicides.
2 Criteria used: Chlorpyrifos CDFG chronic (0.014 ug/L) Diazinon: USEPA chronic and acute (0.10 ug/L).

A comparison of dry weather and wet weather acute toxicity tests suggests that, although significantly fewer wet weather samples have been collected, occurrences of acute toxicity observed in samples collected during wet weather are more frequent and lead to higher rates of complete mortality (Table 30). Figure 2 displays the number of acute water toxicity tests completed in the CCW by month. This figure suggests that toxicity occurs intermittently in the CCW and more frequently in January and February than in other months of the year.

Table 30. Dry Versus Wet Weather Occurrences of Acute Toxicity in the CCW

	Dry Weather	Wet Weather
Number of Events	56	12
Number of Acute Toxicity Tests	244	23
Number of Tests with Acute Toxicity	71	15
% of Tests with Acute Toxicity	29%	65%
Number of Tests with 100% Mortality	29	12
% with 100% Mortality	41%	80%

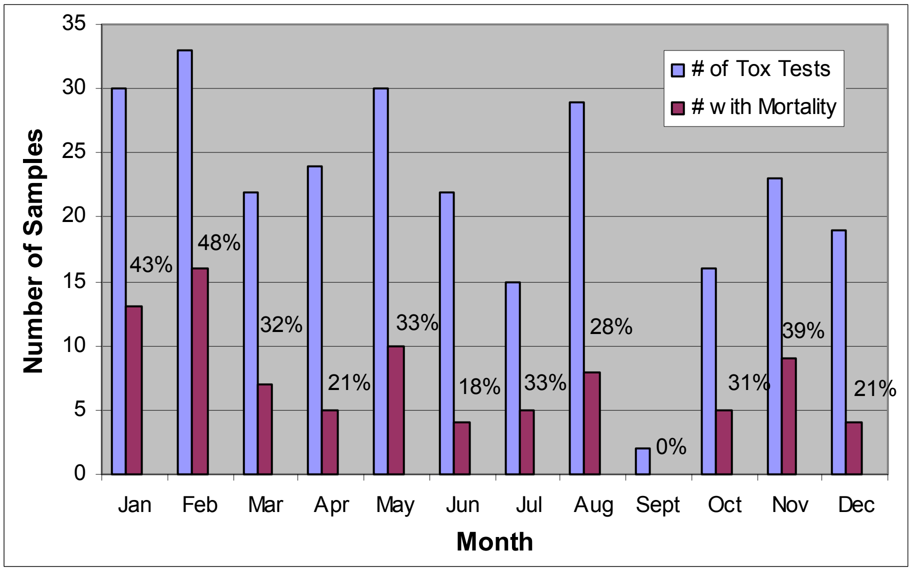

Figure 2. Acute water toxicity by month in all CCW reaches.

3.5 *Sediment Toxicity Summary*

Table 31 presents a summary of acute and chronic toxicity tests and suspected toxicants by reach. Chlorpyrifos and ammonia have been identified as constituents causing acute toxicity (mortality) in sediment in various reaches. The triazine herbicide prometryn has been detected in toxic samples and has the potential to increase toxicity. However, these herbicides were not observed to increase toxicity or cause toxicity on their own. Toxicity of unknown causes continues to be observed in Reach 2 and the toxicant(s) causing toxicity have not been identified. Sediment toxicity observed in Reaches 6, 7, and 10 through the CCCS monitoring program were not confirmed during the TMDL Work Plan monitoring, suggesting that toxicity observed in these reaches is intermittent. The information provided in the Current Conditions section identified toxicity in sediment in the following reaches not on the 2002 303(d) list: 3, 4, and 9A. In addition to the listings presented in the Problem Statement section, this TMDL will address sediment toxicity in these reaches. Figure 3 displays the number of acute sediment toxicity tests completed in the CCW by month.

Table 31. Sediment Toxicity Testing Summary for the CCW

Reach	2002 303(d) Sediment Toxicity Listing	# of acute tests	% with acute toxicity	# of chronic tests	% with chronic toxicity	# porewater tested	% with porewater mortality	Suspected Toxicant(s) identified through TIEs
1	X	74	30%[1]	8	38%	NA	NA	NA
2	X	6	75%	NA	NA	3	33%	Inconclusive
3		6	30%	3	0%	4	75%	Chlorpyrifos and Ammonia[2]
4		6	67%	3	33%	5	60%	Chlorpyrifos and Ammonia[3]
6		5	20%	3	0%	2	0%	Inconclusive[4]
7		5	20%	3	33%	2	0%	Inconclusive[4]
9A		6	50%	3	33%	6	50%	Inconclusive[5]
10		5	20%	3	0%	2	0%	Inconclusive[4]

NA This type of toxicity testing was not conducted in this reach.
1 Not all of the toxicity data available for Reach 1 either indicate the magnitude of mortality and/or the mortality of an environmental sample relative to the control. In an effort to characterize sediment toxicity, where available, toxicity tests with greater than 50% mortality were considered acutely toxic.
2 TIE data suggests sediment toxicity caused by chlorpyrifos may be potentiated, but not solely caused, by the triazine herbicide prometryn and/or ammonia. Additional constituents may contribute to toxicity.
3 TIE data suggests at times sediment toxicity caused by chlorpyrifos may be potentiated, but not solely caused, by the triazine herbicide prometryn and/or ammonia.
4 Based on the available information it is not clear if there is a sediment toxicity impairment in this reach.
5 The potential toxicants contributing to sediment toxicity in this reach were not conclusively identified; however, based on the TIEs; contributing toxicants may include multiple compounds.

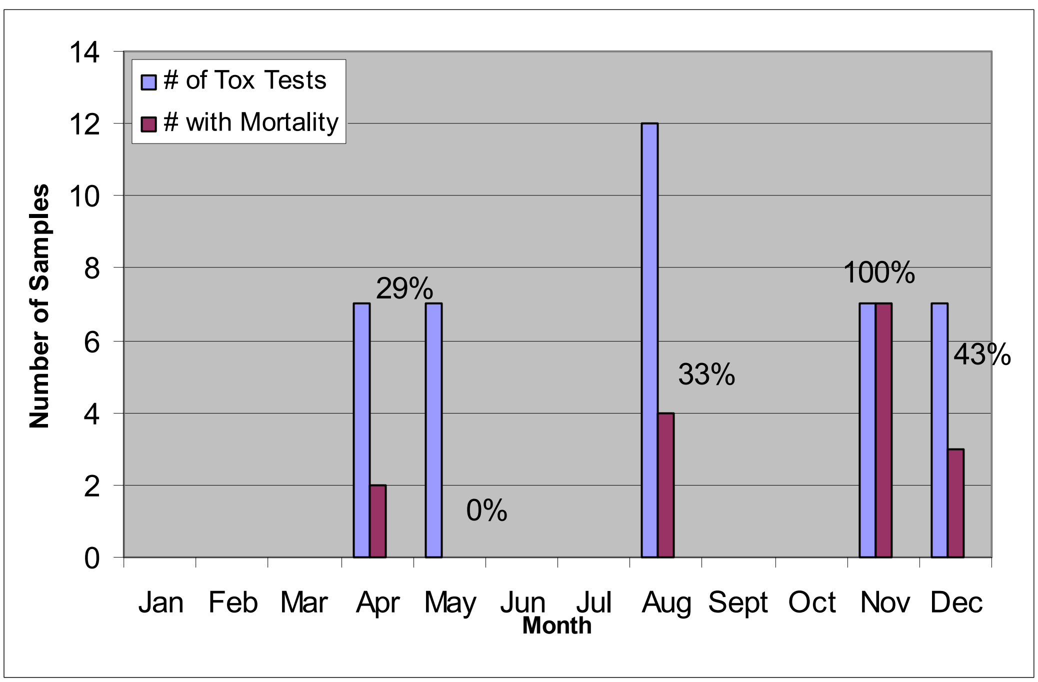

Figure 3. Acute sediment toxicity by month in all CCW reaches.

4 Numeric Targets

To address the constituents identified in the Current Conditions section believed to be contributing to toxicity; this section presents numeric targets for chlorpyrifos and diazinon. In addition, numeric targets for water and sediment toxicity are presented to address current and future occurrences of toxicity of unknown causes. Numeric targets addressing ammonia toxicity in water are presented in the Total Maximum Daily Loads for Nitrogen Compounds and Related Effects: Calleguas Creek, Tributaries, and Mugu Lagoon (LARWQCB, 2002). Although toxicity testing and TIEs have not indicated organochlorine pesticides or PCBs are contributing to toxicity in water or sediment, numeric targets presented in the CCW Organochlorine Pesticides and PCBs TMDL Numeric Targets section will address the potential contribution of toxicity attributable to 303(d) listed organochlorine pesticides and PCBs. The numeric targets for chlorpyrifos, diazinon, and toxicity are values that will result in the protection of beneficial uses. If additional constituents are identified as contributing to water and/or sediment toxicity and these constituents are not appropriately addressed by other TMDLs, numeric targets will need to be developed.

4.1 *Ammonia Targets*

As discussed above, ammonia toxicity in water has been addressed through the Total Maximum Daily Loads for Nitrogen Compounds and Related Effects: Calleguas Creek, Tributaries, and Mugu Lagoon (CCW Nutrients TMDL) (LARWQCB, 2002). The targets presented in the CCW Nutrients TMDL were developed using the revised ammonia objectives set forth in the *Amendment to the Water Quality Control Plan for the Los Angeles Region to Update the Ammonia Objectives for Inland Surface Waters (including enclosed bays, estuaries and wetlands) with Beneficial Use designations for protection of "Aquatic Life" Resolution 2002-011 April 25, 2002*. This amendment revising the ammonia objectives was based on the USEPA's *1999 Update of Ammonia Ambient Water Quality Criteria for Ammonia*. The targets in the CCW Nutrients TMDL will be used to address toxicity associated with ammonia unless additional monitoring determines they are not removing toxicity due to ammonia in the watershed. As discussed in the Current Conditions section, ammonia in sediments may be contributing to toxicity in Reaches 3 and 4. Numeric targets presented in the CCW Nutrients TMDL are assumed to address all toxic effects of ammonia, including toxicity in sediments. If achievement of those numeric targets does not adequately address these toxic effects, additional targets will be developed through future updates of the CCW Nutrients TMDL.

4.2 *Organochlorine Pesticides Targets*

Although toxicity testing and TIEs have not indicated organochlorine pesticides or PCBs are contributing to toxicity in water or sediment, numeric targets presented in the CCW Organochlorine Pesticides and PCBs TMDL Numeric Targets section will address the potential contribution of toxicity attributable to 303(d) listed organochlorine pesticides and PCBs.

4.3 *OP Pesticides (Chlorpyrifos and Diazinon) Targets*

There are no promulgated water quality objectives for chlorpyrifos or diazinon. An analysis of the alternatives available for numeric targets for these constituents have been conducted through this and previous TMDLs (CVRWQCB, 2001, 2003; SFBRWQCB, 2004). The alternatives included:

1. No observable levels of chlorpyrifos or diazinon;
2. Water quality criteria developed using USEPA's 1985 Guidelines for Deriving Numeric National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses;

3. Water quality criteria developed based on single-species toxicity tests;
4. Probabilistic ecological risk assessment (PERA) methodology; and,
5. Microcosm and mesocosm studies.

The analysis performed by this and previous TMDL efforts found water quality criteria developed using USEPA guidance to be the most appropriate. The reasoning for selecting water quality criteria developed using USEPA guidance (Number 2 above) are 1) that they are based on established guidelines and 2) these criteria are inherently protective of aquatic life because they are based on aquatic toxicity testing. As these guidelines currently provide an accepted approach for developing water quality criteria to protect fish and aquatic invertebrates, the chlorpyrifos and diazinon numeric targets presented in this section are based on water quality criteria developed using USEPA guidance.

4.3.1 Chlorpyrifos Targets

Table 32 presents chlorpyrifos water quality criteria developed using USEPA's 1985 guidelines. Water quality criteria were developed by both the USEPA (1986) and the CDFG (2000) using USEPA guidelines. In developing the water quality criteria, the USEPA and the CDFG reviewed acute and chronic toxicity data for at least eight families of aquatic animals as recommended by the USEPA (1985).

Table 32. Existing Chlorpyrifos Water Quality Criteria for the Protection of Aquatic Life

Acute Criteria (1-hour maximum concentration)	Freshwater ug/L	Saltwater ug/L
CDFG[1]	0.025	0.02
USEPA[2]	0.083	0.011
Chronic Criteria (4-day average concentration)		
CDFG[1]	0.014	0.009
USEPA[2]	0.041	0.0056

[1] CDFG, 2000 [2] USEPA, 1986

There is no clear guidance on the appropriateness of selecting the CDFG versus the USEPA criteria for numeric targets. In addition, previously developed TMDLs in other regions of the State provide little reasoning on a methodology for selecting between the two. Consequently, an analysis of the differences between the two criteria was conducted. The CDFG criteria were developed more recently than the USEPA criteria and contain an analysis of a much larger number of studies. More recent studies included a number of tests on sensitive genera, *C. dubia* and *Neomysis*, which were not available when the USEPA criteria were developed. Because the CDFG criteria contain an analysis of a larger range of tests and species and include data from two of the most sensitive genera, the CDFG developed chlorpyrifos criteria were selected as the concentration-based numeric targets.

Numeric Targets for Chlorpyrifos

Freshwater Numeric Targets[1]	
Chronic Criterion: 0.014 ug/L:	The four-day average concentration of chlorpyrifos in freshwater shall not exceed 0.014 ug/L more than once every three years.
Acute Criterion: 0.025 ug/L:	The one-hour average concentration of chlorpyrifos in freshwater shall not exceed 0.025 ug/L more than once every three years.
Saltwater Numeric Targets[2]	
Chronic Criterion: 0.02 ug/L:	The four-day average concentration of chlorpyrifos in saltwater shall not exceed 0.014 ug/L more than once every three years.
Acute Criterion: 0.009 ug/L:	The one-hour average concentration of chlorpyrifos in saltwater shall not exceed 0.025 ug/L more than once every three years.

1 Freshwater targets apply in all reaches of the CCW except for Mugu Lagoon
2 Saltwater targets apply in Mugu Lagoon

Currently there are no criteria or guidelines for use as numeric targets to address chlorpyrifos in fish tissue. Chlorpyrifos in freshwater fish tissue rapidly depurate within several days of removal from exposure (USEPA, 1999). As such, it is assumed that reductions in water column concentrations will result in reductions in levels in fish tissue. In addition, as the chlorpyrifos in fish tissue listings were established to be protective of aquatic life and as the water column numeric targets were also developed to be protective of aquatic life, the water column numeric targets are believed to address the chlorpyrifos in fish tissue listings.

There are no criteria or guidelines for chlorpyrifos in sediment to address associated sediment toxicity. Chlorpyrifos adsorbs strongly to organic matter (log K_{OW} 4.70; mean K_{OC} 6070) (USEPA, 1999) and certain types of fine clay sediments (Summerfelt, 2001). Because of chlorpyrifos' affinity for particles, this TMDL makes the simplifying assumption that attainment of the water column targets for chlorpyrifos will result in attainment of acceptable chlorpyrifos concentrations in suspended and bottom sediments. That assumption is demonstrated explicitly in the linkage analysis.

The SWRCB is currently developing sediment quality guidelines. Therefore, it is premature to set sediment quality targets in this TMDL. The development of chlorpyrifos sediment quality guidelines will be evaluated for inclusion into the CCW Toxicity TMDL. If implementation actions to attain the chlorpyrifos target in water do not eliminate associated sediment toxicity, further action will be investigated.

As described in the Current Conditions section, there may be instances where toxicity associated with chlorpyrifos is increased due to the presence of other constituents such as ammonia, diazinon, or triazine herbicides. However, the studies that suggest the potential for increased toxicity used concentrations of chlorpyrifos at least twice as high as the acute numeric target (Lindstrom and Lydy, 1997; Belden and Lydy, 2000; Bailey *et al.*, in 2001; Anderson and Lydy, 2002; Clark *et al.*, 2002). In addition, at this time there is no evidence to suggest that conditions in the CCW warrant an adjustment of numeric targets to consider the possibility of additive or synergistic effects. If future monitoring determines these numeric targets do not adequately address toxicity associated with chlorpyrifos, the numeric target may need to be revised.

4.3.2 Diazinon Targets

Table 33 presents water quality criteria available for diazinon developed using USEPA's 1985 guidelines. Water quality criteria were developed by both the USEPA (2000) and the CDFG (2000) using USEPA guidelines. In developing the water quality criteria the USEPA and the CDFG reviewed acute and chronic toxicity data for eight families of aquatic animals as recommended by the USEPA (1985).

Table 33. Existing Diazinon Water Quality Criteria for the Protection of Aquatic Life

Acute Criteria (1-hour maximum concentration)	Freshwater ug/L	Saltwater ug/L
CDFG[1]	0.08	NA
USEPA[2]	0.10	0.82
Chronic Criteria (4-day average concentration)		
CDFG[1]	0.05	NA
USEPA[2]	0.10	0.40

[1] CDFG, 2000 [2] USEPA, 2000a
NA – no saltwater acute or chronic criteria were developed by CDFG due to inadequate data.

As discussed above, there is no clear guidance on the appropriateness of selecting between the criteria, and previously developed TMDLs in other regions of the State provide little reasoning on a methodology for selecting between the two. Unlike the chlorpyrifos criteria, both the USEPA and CDFG criteria were developed during a similar time frame (late nineties) so there are fewer differences between the two datasets used for the analysis. However, the USEPA dataset is larger than the one used by the CDFG. Additionally, the two criteria development processes used different analyses to determine which tests were acceptable. For these reasons, a more detailed analysis of the differences between the two criteria was conducted.

The two major influences on the calculation of both the USEPA and CDFG diazinon criteria are the genus mean acute value (GMAV) for the four most sensitive genera and the total number of genera used in the calculations. For both the USEPA and CDFG criteria, the four most sensitive genera are the same (1-*Gammarus*, 2-*Ceriodaphnia*, 3-*Daphnia*, 4-*Simocephalus*). The differences between the two criteria are the values used for *Ceriodaphnia* and *Daphnia*. In the CDFG criteria document, studies on these two genera were conducted by CDFG and used to determine the GMAV. Although the CDFG studies were not included in the USEPA criteria calculations, apparently because they were not available to USEPA, the USEPA's dataset was still larger for the two genera. In addition, the USEPA GMAVs (0.3773 and 0.902) for these two genera are lower than the CDFG GMAVs (0.44 and 1.06). Meaning that if the USEPA had included the additional CDFG studies the USEPA GMAVs would have been higher thereby resulting in higher criteria. Therefore, the USEPA are based on more conservative GMAVs for the most sensitive genera used to determine the criteria. Additionally, the USEPA criteria calculations use 20 genera as compared to the 15 genera used by the CDFG. This difference in the number of genera appears to be the major difference between the two criteria. If the USEPA criteria are recalculated using only 15 genera, the resulting criteria is almost identical to the CDFG (0.075 μg/L vs. 0.08 μg/L). Conversely, if the CDFG criteria are recalculated using 20 genera, the resulting criteria are identical to the USEPA values. Since the USEPA guidelines (1985) state that all available data should be collected and questionable data should not be used in the development of water quality criteria, the larger USEPA dataset should be used in calculating the criteria. Because the USEPA criteria are based on the larger dataset and the more conservative values for the most sensitive genera, the USEPA-developed diazinon criteria will be the concentration-based numeric targets.[1]

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1 In a letter dated May 19, 2004, from the US Geological Survey (USGS), Columbia Environmental Research Center to Dr. Lenwood Hall at the University of Maryland, Chris Ingersoll (USGS) documents that two studies presenting data on *Gammarus*

Numeric Targets for Diazinon

Freshwater Numeric Targets[1]	
Chronic Criterion: 0.10 ug/L:	The four-day average concentration of diazinon in freshwater shall not exceed 0.10 ug/L more than once every three years.
Acute Criterion: 0.10 ug/L:	The one-hour average concentration of diazinon in freshwater shall not exceed 0.10 ug/L more than once every three years.
Saltwater Numeric Targets[2]	
Chronic Criterion: 0.40 ug/L:	The four-day average concentration of diazinon in saltwater shall not exceed 0.40 ug/L more than once every three years.
Acute Criterion: 0.82 ug/L:	The one-hour average concentration of diazinon in saltwater shall not exceed 0.82 ug/L more than once every three years.

1 Freshwater targets apply in all reaches of the CCW except for Mugu Lagoon
2 Saltwater targets apply in Mugu Lagoon

Diazinon was not identified as causing or contributing to sediment toxicity in the CCW. Diazinon binds only moderately to soil and sediment (K_{OW} 2000 and K_{OC} ~1000-1800) (Ogle, 2004). The SWRCB is currently developing sediment quality guidelines. The development of diazinon sediment quality guidelines will be evaluated for inclusion into the Toxicity TMDL.

As described in the Current Conditions section, there may be instances where toxicity associated with diazinon is increased due to the presence of other constituents such as ammonia, chlorpyrifos, or triazine herbicides. However, the studies that suggest the potential for increased toxicity used concentrations of diazinon at least twice as high as the numeric target (Lindstrom and Lydy, 1997; Belden and Lydy, 2000; Bailey *et al.*, in 2001; Anderson and Lydy, 2002). In addition, at this time there is no evidence to suggest that conditions in the CCW warrant an adjustment of numeric targets to consider the possibility of additive or synergistic effects. If future monitoring determines these numeric targets do not adequately address toxicity associated with diazinon, the numeric target may need to be revised.

4.4 *Water Toxicity Target*

To protect the aquatic life beneficial use in the CCW and meet the Basin Plan narrative toxicity objective, causes of toxicity observed in ambient water in the watershed must be identified when possible. The Basin Plan narrative toxicity objective does not allow acute toxicity in any receiving waters or chronic toxicity outside designated mixing zones and states that limits for specific toxicants can be established to control toxicity identified under Toxicity Identification Evaluations (TIEs). The targets for the constituents listed above are designed to address toxicity that has been identified in the watershed to date. However, toxicity

fasciatus [Johnson and Finley (1980) and Mayer and Ellersieck (1986)] reported the 96-h LC_{50} of 0.2 ug/l. The 96-h LC_{50} of 0.2 ug/l presented in these two studies were used to develop both the USEPA and CDFG water quality criteria. However, a recent review of the original data sheets from tests conducted on March 18, 1966 by the USGS found what appears to be an error and that the 96-h LC_{50} should have been reported as 2.0 ug/l. Because of this apparent error, both the USEPA and CDFG diazinon criteria are questionable. The Central Valley Regional Board considers the use of revised CDFG diazinon criteria, which do not use the questionable data, in the Peer Review Draft Staff Report for the San Joaquin River OP Pesticide TMDL (2005). The USEPA diazinon criteria may be revised after incorporating comments and additional data submitted by March 30, 2004 as part of the criteria development process. It is anticipated the information regarding the apparent error as well as additional acute and chronic toxicity data (including studies in the CDFG's criteria document) may be considered and may result in a revision to the EPA diazinon water quality criteria. As a result, any revisions to the diazinon water quality criteria can be considered by the Regional Board during the implementation period of the CCW Toxicity TMDL.

of unknown causes may still occur in the future. To meet the narrative toxicity objective, a numeric toxicity target of 1 chronic toxicity unit (1 TUc) is established. A chronic toxicity target was selected because it addresses the potential adverse effects of long term exposure to lower concentrations of a pollutant and is therefore more protective than an acute toxicity target that may not address potential effects of longer term exposures. Equation 1 describes the calculation of a TUc.

Equation 1 TU_c = Toxicity Unit Chronic = 100/NOEC (no observable effects concentration).

The NOEC (no observable effects concentration) is defined in the USEPA's Technical Support Document (TSD) as "the highest concentration of toxicant, in terms of percent effluent, to which the test organisms are exposed, that causes no observable adverse effect" (USEPA, 1991). To calculate the TUc: TUc = 100% ÷ the sample concentration, derived using hypothesis testing, to cause no observable effect, with the sample concentration expressed as a percentage. For example, if a chronic test is conducted using a dilution series (a series of original samples diluted to various concentrations) of 100%, 50%, 25%, 12.5%, and 6.25% and the lowest observed effect concentration (LOEC = lowest concentration of toxicant to which the test organisms are exposed that causes an observed effect derived using hypothesis testing) is 25% then the NOEC is estimated to be 12.5% using hypothesis testing. Therefore, the TUc would equal 100/12.5 = 8 toxic units.

4.4.1 Alternatives Considered for Water Toxicity Target

Two alternatives were considered in developing the toxicity numeric target. These alternatives were 1) calculating the TUc using a statistically derived "no observable effects concentration" (NOEC) using hypothesis testing and 2) calculating the TUc using a point estimate such as an inhibition concentration (IC). The second alternative (IC25) is recommended by USEPA's TSD (1991) for several reasons including:

- The IC_{25} value represents a point estimate that interpolates effects from actual sample concentrations at which measured effects occur during a chronic test;
- The IC_{25} is not dependent upon the selection of the concentrations of the samples tested; and,
- A coefficient of variation can be calculated for ICs as they are point estimates as opposed to a statistically derived NOEC using hypothesis testing for which no estimates of precision can be calculated.

However, alternative one was the selected alternative as it is consistent with current Los Angeles Regional Board and USEPA NPDES permitting practice. If the Regional Board revises NPDES permits to calculate a TUc using inhibition concentrations (ICs) or other point estimate methodology, the Regional Board may reconsider the water toxicity numeric target.

4.5 *Sediment Toxicity Target*

To protect the aquatic life beneficial use in the CCW and meet the Basin Plan narrative toxicity objective, causes of toxicity observed in sediment in the watershed must be identified when possible. The Basin Plan narrative toxicity objective states that limits for specific toxicants can be established to control specific pollutants identified as causes of toxicity. The targets for the constituents listed above are assumed to address toxicity that has been identified in the watershed to date. However, toxicity of unknown causes may still occur in the future, and a numeric sediment toxicity target is established to allow objective evaluation of the narrative toxicity objective. Because sediment toxicity tests do not provide point estimates (e.g. IC25 or LC50), sediment toxicity targets can not be expressed as a specific toxicity unit (TU) threshold value as recommended for aquatic toxicity. Therefore, the proposed sediment toxicity target is set at no observable sediment toxicity with sediment samples defined as toxic if the following two criteria are met: 1) there is a significant difference ($p<0.05$) in mean organism response (e.g., percent survival) between a sample and the control as determined using a separate-variance t-test, and 2) the mean organism response in the toxicity test (expressed as a percent of the laboratory control) was less than the threshold based on the 90th percentile Minimum Significant Difference (MSD) value expressed as a percent of the control value.

For the purpose of setting a consistent and objective target for sediment toxicity, the proposed approach is based on the September 2004 *Water Quality Control Policy For Developing California's Clean Water Act Section 303(d) List* (SWRCB, 2004c). The guidance allows for a selection between either of the two criteria listed above to define a sediment sample as toxic. This TMDL implements this guidance in a manner similar to the BPTCP (SWQCB, 1998) and work completed for the San Francisco Estuary Institute (Thompson *et al.*, 1997) by using both criteria. A determination of statistical significance is a necessary and standard requirement for any toxicity test. However, statistical significance is dependent on the variability of test replicates for each test as well as the magnitude of the difference between the sample and the control. As a result, the magnitude of toxic effect considered "significant" varies for each individual test and in cases where replicate variability is low, very small differences from controls can be statistically significant, even when they may not be biologically or ecologically relevant. The primary purpose of the second tier MSD criterion for toxicity is to provide a less variable toxicity target. While the MSD is still a function of the statistical characteristics of a specific test protocol, it has the advantage of providing a more consistent target that has a greater likelihood of being biologically and ecologically relevant.

The 90^{th} percentile MSD value is specific for each specific toxicity test protocol and is determined by identifying the magnitude of difference that can be detected 90% of the time by a specific test method (Schimmel *et al.*, 1994; Thursby and Schlekat, 1993). This is equivalent to setting the level of statistical power at 0.90 for these comparisons. Determining the MSD for the toxicity target is accomplished by determining the MSD for each individual t-test conducted, and identifying or estimating the upper 90^{th} percentile MSD (the MSD that is larger than or equal to 90% of the MSD values generated). The 90^{th} percentile MSD values developed by the BPTCP (SWQCB, 1998) range from as low as 10% to as high as 45%, which translates to minimum detectable percent differences from controls of 90% to 55% Table 34. If there are sufficient toxicity test results available for the CCW, the MSD used for the toxicity target can be derived from these data. Otherwise, most of the BPTCP MSD values are based on a large number of individual tests and provide a reasonable benchmark for the toxicity target MSDs for individual test methods.

The following is a description of MSDs and how a toxic effect would be identified (SWRCB, 1996):

> "In toxicity tests, the MSD represents the smallest difference between the control mean and a treatment mean (the effect size) that leads to the statistical rejection of the null hypothesis (H_0: no difference). Any effect size equal to or larger than the MSD would result in a finding of statistically significant difference. For example, if the control mean for mysid growth were 80 ug/mysid and the MSD were 20, any treatment with mean mysid weight less than or equal to 60 ug would be significantly different from the control and considered toxic."

Table 34. Range of MSD Values as Reported in *Sediment Chemistry, Toxicity, and Benthic Community Conditions in Selected Water Bodies of the Load Angeles Region* (SWRQCB, 1998)

Species	Name	MSD	% of Control	N
Ee	Eohaustorius	25	75	385
Hr	Haliotis (5 reps)	10	90	131
Hr	Haliotis (3 reps)	36	64	336
Hr	Haliotis (all reps)	32	68	467
Me	Mytilus	20	80	223
Na Sv	NEanthes Sv	36	64	335
Na Wt	NEathes Wt	56	44	335
Ra	Rhepoxynius	23	77	720
Sp Dev	Urchin Dev (5 reps)	22	78	309
Sp Dev	Urchin Dev (3 reps)	45	55	630
Sp Dev	Urchin Dev (all)	40	60	939
Sp Fert	Urchin Fert	12	88	79
Sp SWI	Urchin SWI	41	59	109

The State Board is currently developing sediment quality guidelines. The development of relevant sediment quality guidelines as they relate to the definition of sediment toxicity will be incorporated into the CCW Toxicity TMDL, if appropriate.

5 Source Analysis

The Source Analysis section includes a discussion of the potential sources of chlorpyrifos and diazinon as these two OP pesticides have been identified as causing water and/or sediment toxicity in the CCW. Potential contributions to toxicity from ammonia are addressed by the CCW Nutrients TMDL. Although toxicity testing and TIEs have not indicated organochlorine pesticides or PCBs as contributing to toxicity in water or sediment, a source analysis of 303(d) listed organochlorine pesticides and PCBs is presented in the CCW Organochlorine Pesticides and PCBs TMDL.

As presented in the Current Conditions section, the cause(s) of unknown toxicity in listed reaches have not been fully identified. Based on toxicity investigations the constituents causing unknown toxicity are likely organic in nature and possibly pesticides. These pesticides could include other OP pesticides, replacement pesticides for OP pesticides (i.e. pyrethroids), or some other yet to be identified pesticide that is in itself toxic or potentiates toxicity. Monitoring, as outlined in the Implementation Plan section, will continue to investigate toxicity of unknown causes. If additional constituents are identified as contributing to water and/or sediment toxicity and these constituents are not appropriately addressed by other TMDLs, a source analysis will be conducted.

5.1 *Data Resources*

Several data resources were used to identify and quantify potential sources of diazinon and chlorpyrifos to the various reaches in the CCW. The primary data resources used for this analysis include pesticide use and sales data from the California Department of Pesticide Regulation (DPR) and water quality data from a variety of monitoring programs.

5.1.1 Use of Environmental Data in Source Analysis Section

Water quality data that can be correlated to land use have been gathered through a variety of monitoring programs and incorporated in the CCW Database (LWA, 2004a). Table 35 presents a summary of the available water quality data used to investigate contributions of chlorpyrifos and diazinon to water from various land uses.

Table 35. Summary Table of Land Use Discharge Data Sources Used in Source Analysis for Chlorpyrifos and Diazinon

Data Source[1]	Begin Date	End Date	Urban Land Use Sites	Agricultural Land Use Sites	Groundwater Sites	POTW
205(j) Non Point Source Study (LWA, 2004a)	11/98	5/99	X	X		
Calleguas Creek Characterization Study – CCCS (LWA, 2000)	8/98	5/99	X	X	X	X
CCW TMDL Work Plan Monitoring Plans	8/03	8/04	X			
Camarillo WRP (LWA, 2000)[2]	8/98	5/99				X
Hill Canyon WWTP (LWA, 2000)[2]	8/98	5/99				X
Moorpark WWTP (LWA, 2000)[2]	9/97	11/98				X
Olsen Road WRP (LWA, 2000)[2]	8/98	5/99				X
Simi Valley WQCP (LWA, 2000)[2]	8/98	5/99				X
Ventura County Watershed Protection District – VCWPD (VCWPD 1998-2004)	3/94	2/04	X	X		

1 Complete references for these studies are provided in the References section of this report when available.
2 The only available chlorpyrifos and diazinon data characterizing POTW effluent were collected one year period, primarily through the CCCS.

5.1.2 Development of Summary Statistics

As discussed in the Current Conditions section, a large proportion of data used to develop the summary statistics for this TMDL are non-detected data. The ROS method was selected to deal with the inherent uncertainty in characterizing the true range of conditions in instances where a large portion of the data are non-detected. For a more detailed discussion of the ROS method, please see the Development of Summary Statistics section presented in the Current Conditions section. As mentioned previously in the Current Conditions section, because of limited available data, grab and composite samples are treated in the analysis as equivalent and equally representative of the sampled water, also estimated and qualified data are used as normal detected values.

5.1.2.1 Environmental Data Used

The available land use data compiled in the CCW Database (LWA, 2004a) were used to develop the source analysis summary statistics. The bulk of the data cited in Table 35 were used in this analysis. A large proportion of data used are non-detected data. However, the ROS method has defined data requirements for developing summary statistics. Due to the number of non-detected values at relatively high detection limits the ability to develop summary statistics was limited. To develop summary statistics to characterize water quality in each reach non-detected samples were removed when detection limits were higher than concentrations considered characteristic of individual land use sites based on detected values. Table 36 presents the number of samples removed by land use site as well as the range of detection limits removed.

Table 36. Number of Non-Detect Values Removed Due to High Detection Limits from Land Use Sampling Sites

Sample Station Type	Number of Non-Detect Samples Removed due to High Detection Limits		Range of Removed DLs (ug/L)	
	Diazinon	Chlorpyrifos	Diazinon	Chlorpyrifos
Effluent Discharge	1	0	2	
Commercial Runoff	1	1	50	100
Industrial Runoff	2	2	50	100
Residential Runoff	2	2	50	100
Agricultural Runoff	10	1	2	2
Total Number Removed	**16**	**6**		

5.1.3 Pesticide Use Data

Pesticide Use Report (PUR) data from DPR provide detailed information about pesticide application rates according to crop types for each county in the state. Prior to 1990, limited use reporting requirements existed. In 1990, California began requiring full use reporting for all agricultural pesticide use and commercial pest control applications. These data are reasonably comprehensive and accurate for agricultural, restricted, and commercial applications. As outlined in the *Summary of Pesticide Use Report Data – 2002*, the following pesticide uses are considered "reported uses" requiring applicators to submit detailed use reports to the County Agricultural Commissioner:

- For the production of any agricultural commodity, except livestock;
- For the treatment of post-harvest agricultural commodities;
- For landscape maintenance in parks, golf courses, and cemeteries;
- For roadside and railroad rights-of-way;
- For poultry and fish production;
- Any application of a restricted material;
- Any application of a pesticide with the potential to pollute ground water (listed in section 6800(b) of the California Code of Regulations, Title 3, Division 6, Chapter 4, Subchapter 1, Article 1) when used outdoors in industrial and institutional settings; and,
- Any application by a licensed pest control operator.

Exclusions from reporting requirements include industrial, institutional, and residential landscape and garden pesticide uses. These uses are collectively referred to as "unreported uses". Published PUR data contain extensive information about the quantities and types of pesticides used in each county, as well as information about the acreage and types of crops treated. These data are collected by county agriculture commissioners in most counties and then passed along to DPR for QA/QC and database management. Analysis of PUR data in this document examines the years 1998-2003.

5.1.4 Pesticide Sales Data

Pesticide registrants, pest control dealers and pesticide brokers are mandated to report the total dollar value and total pounds or gallons of each product they sell for use in California. The active ingredient in any pesticide product is the chemical or chemicals that kill or otherwise controls target pests. Regulations require that when there are three or fewer registrants reporting sales of a pesticide product containing the same active ingredient, such reports are considered trade secrets and cannot be disclosed by DPR. Sales data do provide a cumulative sales total for all active ingredients, disclosed and undisclosed, including: insecticides, miticides, fumigants, nematicides, rodenticides, desiccants, defoliants, growth regulators, herbicides, bactericides, antimicrobials, algicides, and fungicides. Also included in the total are chemical adjuvants, which are considered pesticides under California law; these include emulsifiers, spreaders, water modifiers, and other chemicals added to pesticides to enhance their effectiveness. Pesticides sales data are not categorized by county or city; rather, the sales data are only available for the State as a whole.

5.2 *Land Use*

There are about 344 square miles in the CCW, approximately 51% of which is utilized by some form of human activity (DWR, 2000). About half of these utilized lands are urban or urban landscape, and about half are used for agriculture (Figure 4). The non-utilized land is comprised of native vegetation (96%), as well as waterbodies and barren or idle lands. The category ‘urban landscape’ includes cemeteries, golf courses, and other urban lawn areas. Agricultural lands primarily yield truck crops and citrus. Lemons, avocados, strawberries, green beans, celery, and onions are the most common crops. The term “truck crop” describes vegetables grown in furrows that go straight to market when harvested (e.g. green beans, peppers, celery, tomatoes), and the term “field crop” indicates crops such as cotton, flax, hops, and sugar beets that do not necessarily go straight to market. A detailed list of all land use types existing in the watershed by subcategory and acreage is found in Appendix II. In recent decades the CCW has experienced dramatic growth in urban residential and commercial development, but historically a much larger percentage of land was used for farming.

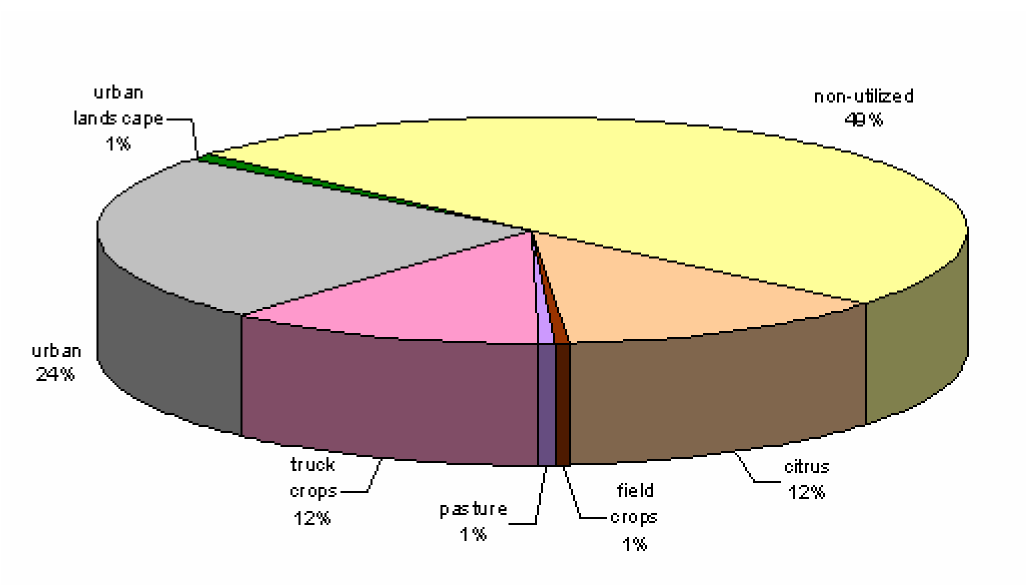


Figure 4. Land use in CCW (Department of Water Resources, 2000 land use layer).

5.2.1 Urban Land Use

About two thirds of the urban lands within the watershed are residential, situated mostly in the central to upper portions of the watershed (Table 37, Figure 6). Less than three percent of all land in the watershed is dedicated to industrial and commercial purposes combined.

Table 37. Breakdown of Urban Land Use in CCW (SCAG, 2000 land use layer)

Urban Land Uses	Acres[1]	% of Urban Land Use	% of Watershed Area
Residential	28,898	68%	13%
Transportation & Utilities	5,003	12%	2%
Public Facilities & Institutions	4,063	10%	2%
Industrial	2,403	6%	1%
Commercial	2,399	6%	1%

1 The SCAG land use classification system is not identical to that of California Department of Water Resources, which is used for all other land use analysis in this document.

5.2.2 Agricultural Land Use

Current agricultural land uses vary spatially according to such factors as proximity to the coast, altitude, slope, and soil type. Figure 7 shows specific crop types grown in the area, according to subcategory. Citrus crops such as lemons, oranges, and avocados (considered citrus crops in land use maps) commonly occur in flat or gently sloping foothill areas that are slightly inland. Avocado orchards tend to be located upslope of lemon groves and oranges are usually grown further inland than lemons. Floodplain areas are currently predominated by a wide range of truck crops such as strawberries, peppers, green beans, celery, onions, garlic, lettuce, melons, and squash; as well as turf farms and various types of nurseries. The uppermost portions of the watershed are not cultivated extensively.

Agricultural activities in the watershed are somewhat challenging to characterize at a fine scale due to several factors. Although some changes in crop composition occur slowly over many years (such as conversion of field crops to truck crops and the disappearance of walnut groves, both during the period 1932-1969), there are also constant changes in crop selection from year to year as farmers adjust to fluctuating market prices or strive to preserve soil by rotating their crops/fields. Additionally, many fields are used to grow successive crops during a single calendar year. This multi-cropping technique is most common in the lower parts of the watershed, adjacent to Revolon Slough and Lower Calleguas Creek. Fields that are multi-cropped do not always follow a time interval that begins and ends within the course of a calendar year. For example, it is common to grow three crops of strawberries in a two year period with some other crop such as barley following the first two strawberry harvests. Growers of turf often plant celery, cabbage or cauliflower in rotation with turf crops to reduce the negative effects upon soil that occur when turf is harvested (personal communication, McIntyre). Agricultural activity within the Oxnard Plain is spatially heterogeneous with highly variable multi-cropping activity.

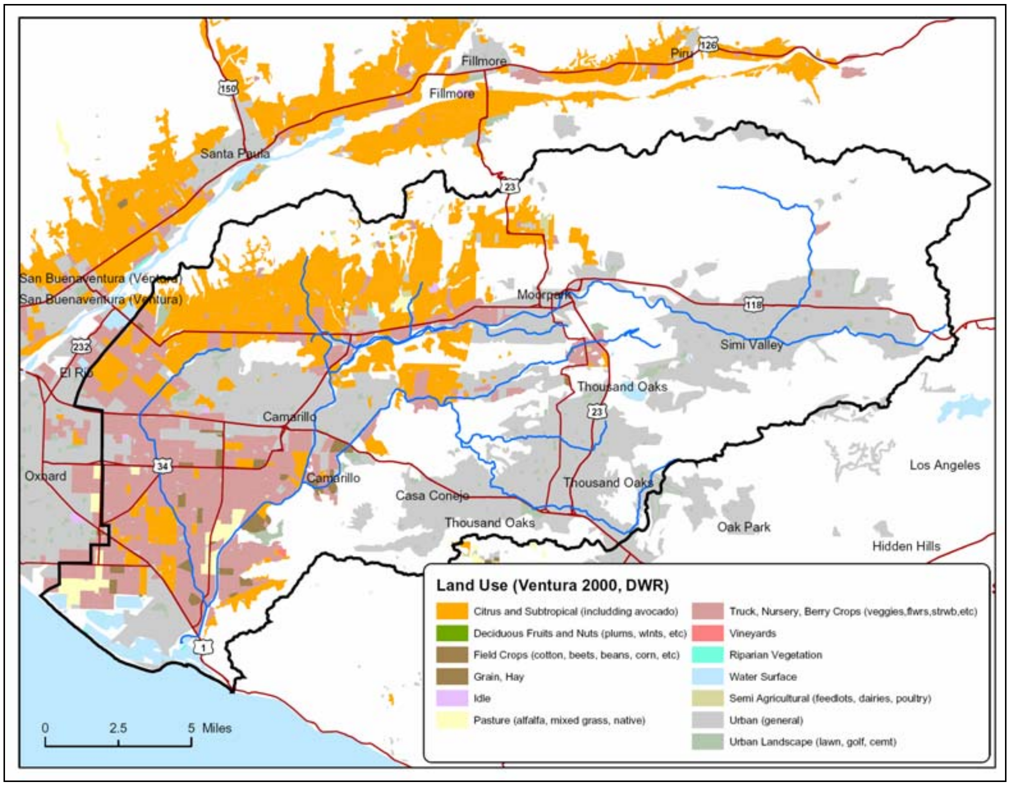


Figure 5. Land use in the CCW, 2000 (California Department of Water Resources).

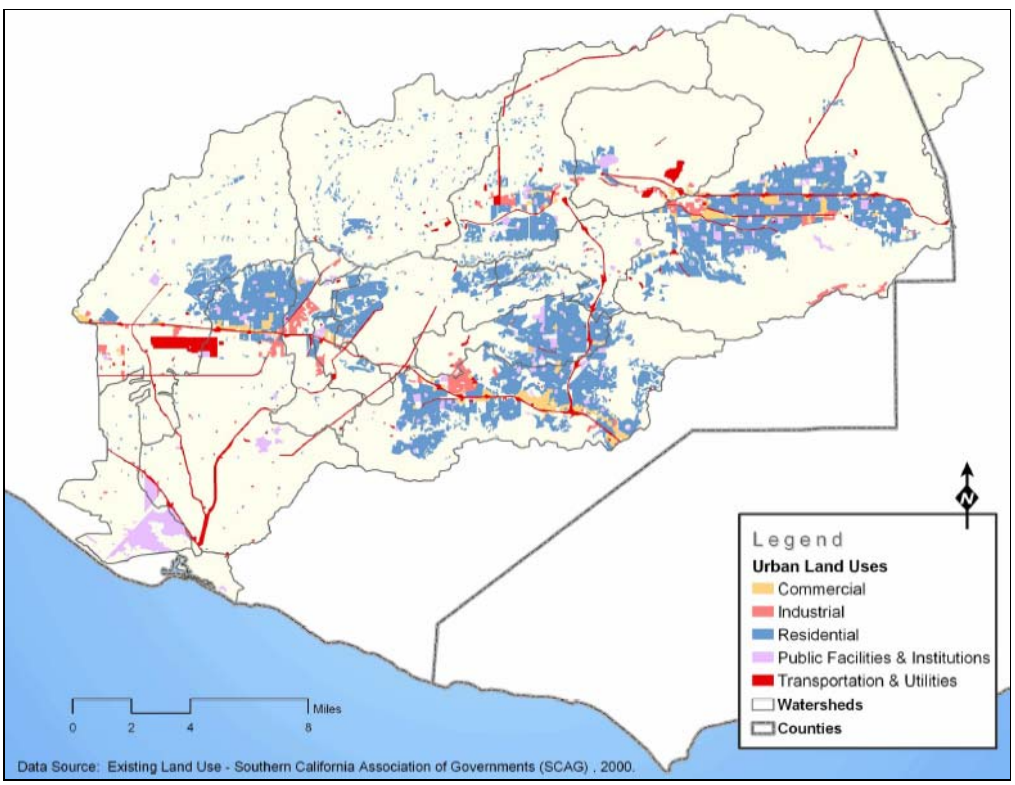


Figure 6. Urban land uses in the CCW (SCAG 2000).

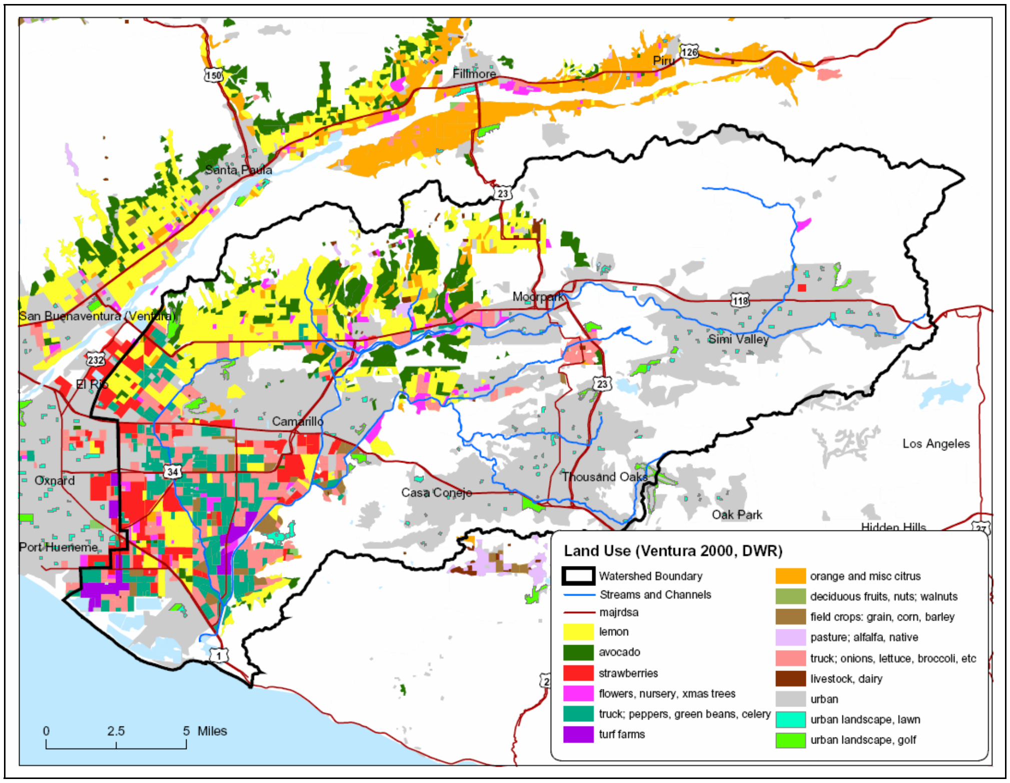


Figure 7. Land use in the CCW by specific crop, 2000 (California Department of Water Resources).

5.3 *Sources of Diazinon and Chlorpyrifos to Calleguas Creek Watershed*

Potential sources of diazinon and chlorpyrifos to waterways in the CCW include urban and agricultural discharges, POTWs, groundwater, atmospheric deposition, imported water, and native space runoff. Each of these potential sources is addressed in the following section.

5.3.1 Diazinon and Chlorpyrifos Use in Calleguas Creek Watershed

Diazinon and chlorpyrifos use in the CCW were analyzed using DPR's PURs for 1998 through 2003. PURs were used to estimate the total reported pounds of these pesticides applied in the CCW over this period, the uses of these pesticides, and temporal and spatial trends.

5.3.2 Phase Out of Uses

In June of 2000 and January of 2001, separate *Revised Risk Assessment and Agreement with Registrants* documents (USEPA, 2000b, 2001a) were released by the USEPA for chlorpyrifos and diazinon, respectively. These agreements, between the registrants/manufacturers and the USEPA, resulted in the modification of uses of these pesticides. To reduce residential risks of exposure from diazinon, retailers stopped sales of products registered for indoor use in December of 2002. In addition, sales to retailers of outdoor non-agricultural use products were completely phased out during 2003 with registrants buying back existing products commencing December 31, 2004. To reduce residential risks of exposure from chlorpyrifos, the agreement resulted in the classification of new end-use products and cancellation of some pre- and post-construction uses, home and lawn, and most other outdoor uses. To reduce non-residential risks of exposure from chlorpyrifos, uses in areas where children could be exposed were cancelled. The modifications to non-agricultural uses will likely result in removing all of the unreported uses of diazinon in 2004 and unreported uses of chlorpyrifos in 2005.

In addition, 30% of 2001 agricultural uses of diazinon were to be cancelled based on the agreement. Agricultural uses of chlorpyrifos were modified to reduce and/or cancel applications to apples, tomatoes, and grapes. Table 38 summarizes the provisions of the diazinon and chlorpyrifos revised risk assessments.

Additional use modifications for chlorpyrifos have been approved by the USEPA, but not yet approved by DPR. These modifications will change application practices for growers and will likely take effect before this TMDL implementation is completed. The label changes include buffer zones for the various application methods, limits on the total applications per year and the pounds per application. Use modifications for diazinon are currently under negotiations between the manufacturer and the USEPA. As the uses of diazinon and chlorpyrifos continue to change, the potential impacts on this TMDL will be addressed through actions in the Implementation Plan.

Table 38. Summary of Provisions of Diazinon and Chlorpyrifos Revised Risk Assessments (USEPA 2000, 2001a)

Use	Restriction
Chlorpyrifos	
Home and Non-Residential Use Restrictions	
Home lawn and most other outdoor uses; crack and crevice and most other indoor uses; full barrier (whole house) post-construction use as termiticide; indoor areas where children could be exposed (such as schools); outdoor areas where children could be exposed (such as parks).	**December 1, 2000:** Stop formulation **February 1, 2001:** Formulators stop sale **December 31, 2001:** Retailers stop sale
Spot and local post-construction use as a termiticide.	**December 1, 2000:** Stop formulation unless label has stop use date of December 31, 2002
Pre-construction use as a termiticide.	December 31, 2004: Stop production December 31, 2005: Stop use
Non-Agricultural Uses	
Indoor areas where children will not be exposed and outdoor areas where children will not be exposed including (golf courses, road medians, industrial plant sites, non-structural wood treatments, and public health uses for fire ant mounds and mosquito control).	**December 1, 2000:** New end-use product labels must reflect only these uses
Agricultural Uses	
Apples	**August – September, 2000:** Production of chlorpyrifos products labeled for post-bloom application is prohibited (only production for pre-bloom, dormant application is allowed) **December 31, 2000:** Post-bloom use is prohibited and tolerance will be lowered
Tomatoes	**August - September 2000:** Production of products for tomato use is prohibited **December 31, 2000:** Stop use, use will be canceled and tolerances will be revoked
Grapes	Tolerances will be revoked
All Agricultural Uses	**December 1, 2000:** Classify new end-use products for restricted use or package in large containers. New end-use products must bear revised Restricted Entry Intervals (REIs)
Diazinon	
Home Uses	
All indoor uses	**February 2001:** Cancellations effective after 30 day public comment period **March 1, 2001:** Manufacturing use products may no longer be used to formulate end use products for indoor uses. **December 31, 2002:** Retailers stop sales
Outdoor Non-Agricultural Uses	**2003:** Production phase down of 50% **June 30, 2003:** Stop formulation **August 31, 2003:** Retailers stop sales **December 31, 2004:** Commence buy back from retailers and expiration of product registrations
Agricultural Uses	
Alfalfa, Bananas, Beans (dried), Bermudagrass, Celery, Red Chicory (radicchio), Citrus, Clover, Coffee, Cotton, Cowpeas, Cucumbers, Dandelions, Kiwi, Lespedeza, Parsley, Parsnips, Pastures, Peppers, Irish Potatoes, Sweet Potatoes, Rangeland, Sheep, Sorghum, Spinach, Squash (summer and winter), Strawberries, Swiss chard, Tobacco, Tomatoes, Turnips	**January 10, 2001:** Proposed deletion of uses **February 2001:** Proposed cancellations may become effective after 30-day comment period.

5.3.3 Agricultural Use

Between 1998 and 2003, over 36,000 pounds of diazinon and 212,000 pounds of chlorpyrifos were reported to have been used for agricultural purposes in the CCW on a variety of crops (Table 39 and Table 40). Figure 8 and Figure 9 present total pounds of diazinon and chlorpyrifos applied in the CCW from 1998 through 2003 as well as reported monthly use. As indicated in Figure 8, the total annual use of diazinon has steadily declined between 1998 and 2003 (47 percent). Decreases in diazinon use between 2000 and 2003 average 9 percent per year and could be attributed to the phase-out of uses. The total amount of chlorpyrifos used in agriculture has remained relatively stable between 1998 and 2003 (Figure 9). The majority of diazinon applications occur in the spring between April and May, historically averaging 66 percent of total applications for the year. The majority of chlorpyrifos applications occur in the late summer to fall between August and November, historically averaging 79 percent of total applications for the year. Figure 10 and Figure 11 present spatial representations of agricultural use of diazinon and chlorpyrifos in the CCW, respectively.

Table 39. Diazinon - Top 15 Crops by Pounds Active Ingredient Applied from 1998 – 2003 (DPR)

Rank	Crop	Pounds of Active Ingredient (AI) Applied	% of Total[1]
1	Beans	17,489.2	45.5%
2	Onion	6,706.5	17.4%
3	Corn	2,209.4	5.7%
4	Lettuce	1,806.0	4.7%
5	Spinach	1,020.9	2.7%
6	Raspberry	1,007.4	2.6%
7	Cabbage	966.0	2.5%
8	Parsley	875.6	2.3%
9	N-Outdr Plants In Containers	844.6	2.2%
10	N-Grnhs Flower	835.9	2.2%
11	Cucumber	734.8	1.9%
12	N-Outdr Flower	623.5	1.6%
13	Broccoli	532.6	1.4%
14	Radish	503.8	1.3%
15	Squash	482.6	1.3%
	Total	36,639	95.3%

Table 40. Chlorpyrifos - Top 15 Crops by Pounds Active Ingredient Applied from 1998 – 2003 (DPR)

Rank	Crop	Pounds of Active Ingredient (AI) Applied	% of Total[1]
1	Lemon	167,957.3	78.6%
2	Strawberry	14,019.6	6.6%
3	Broccoli	11,928.6	5.6%
4	Corn	6,237.5	2.9%
5	Cabbage	4,007.6	1.9%
6	Orange	2,975.0	1.4%
7	Radish	1,580.4	0.7%
8	Chinese Cabbage (Nappa)	867.6	0.4%
9	Onion, Dry	837.9	0.4%
10	N-Outdr Flower	631.2	0.3%
11	N-Outdr Plants In Containers	466.0	0.2%
12	Bean	444.2	0.2%
13	Collards	331.2	0.2%
14	Cauliflower	279.0	0.1%
15	Bok Choy	233.1	0.1%
	Total	212,796	99.6%

1 Use of diazinon and chlorpyrifos on top 15 crops do not equal 100% of use for agricultural purposes

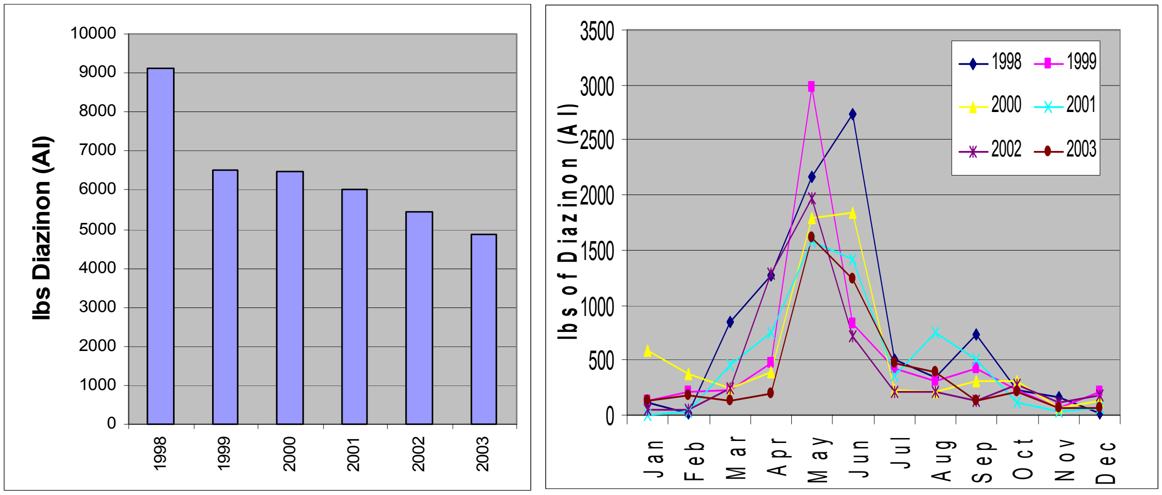


Figure 8. Reported diazinon agricultural use in CCW by year and month from 1998 – 2003 (DPR).

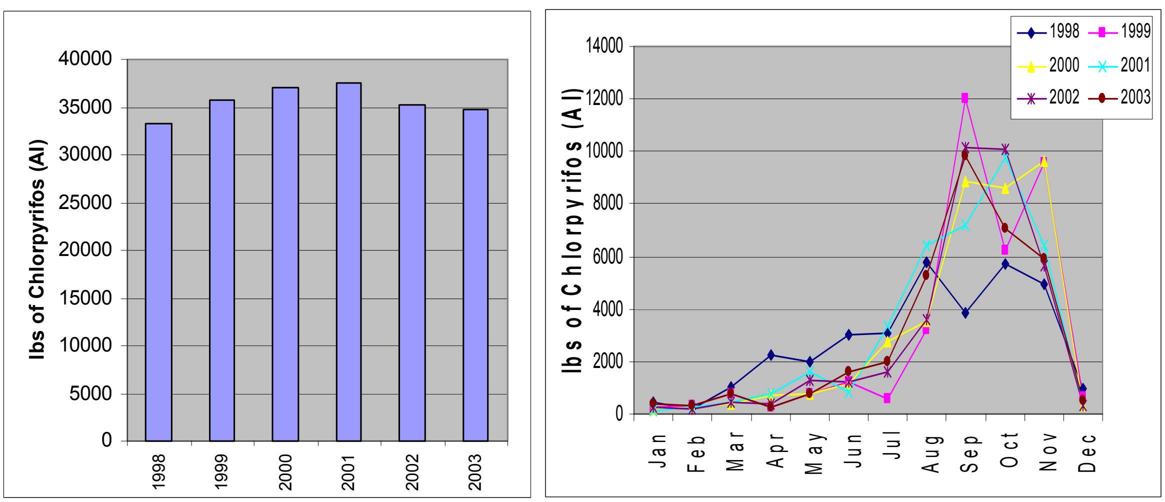


Figure 9. Reported chlorpyrifos agricultural use in CCW by year and month from 1998 – 2003 (DPR).

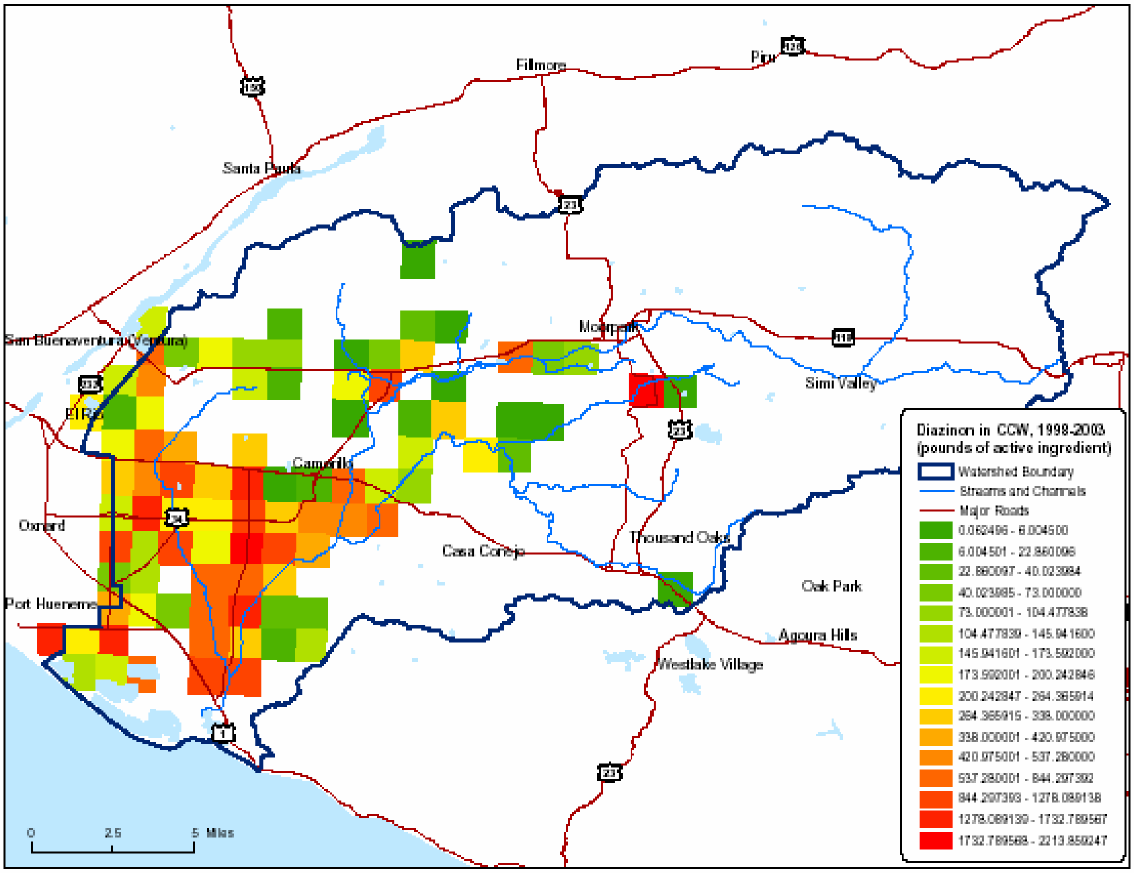


Figure 10. Cumulative agricultural diazinon use in the CCW from 1998-2003 (DPR).

Figure 10 shows the cumulative agricultural diazinon use in the CCW from 1998 – 2003. The majority of agricultural diazinon use occurs in the lower watershed. In comparing Figure 10 to Figure 7 (land use), one can see a correlation with the majority of use of diazinon in the Oxnard Plain, an area of concentrated agricultural activity. The Oxnard Plain is dominated by crops that constitute the bulk of diazinon use in the watershed, such as strawberries, beans, onions, lettuce, and squash (Table 39). The areas of relatively heavier use lie primarily along Revolon Slough (Reach 4) and Calleguas Creek (Reaches 2 and 3). Additionally, there are pockets of relatively higher use along Arroyo Las Posas, Arroyo Simi, Arroyo Santa Rosa (Reaches 6, 7, and 11, respectively).

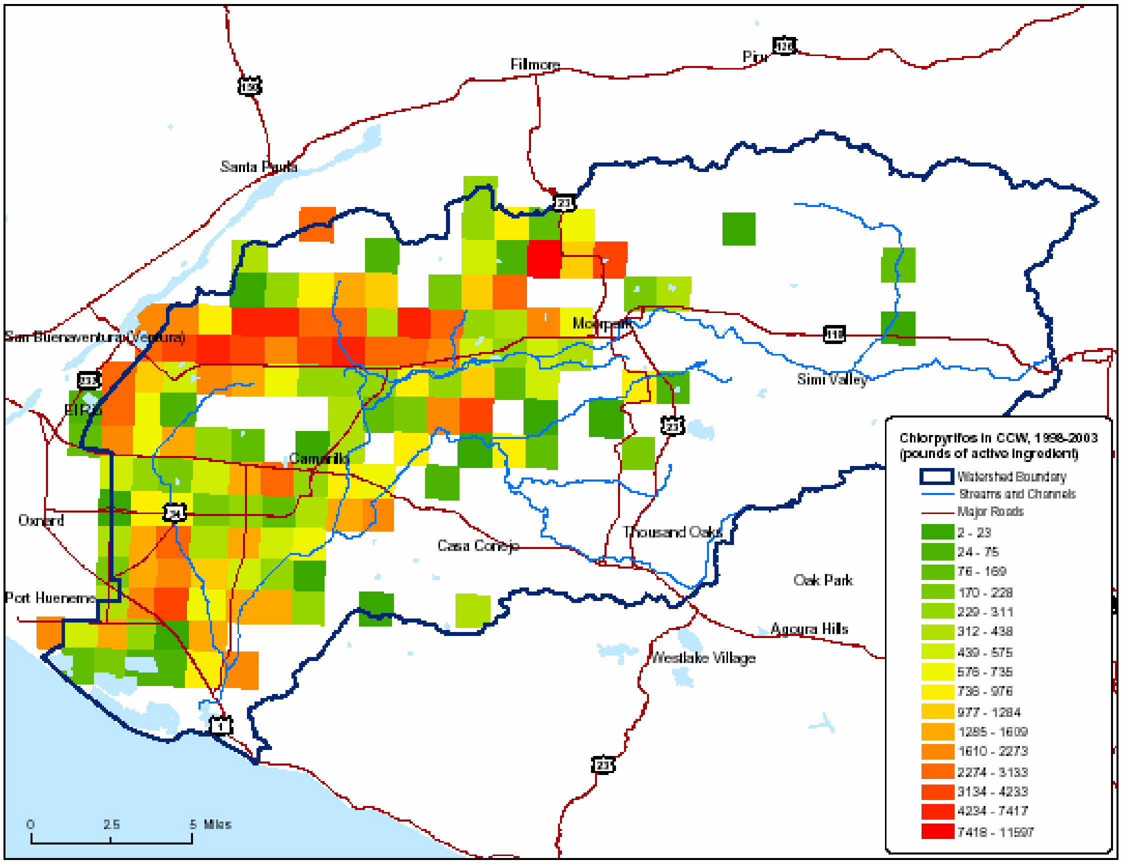


Figure 11. Cumulative agricultural chlorpyrifos use in the CCW from 1998-2003 (DPR).

Figure 11 shows the cumulative agricultural chlorpyrifos use in the CCW from 1998 – 2003. Chlorpyrifos use is more spatially distributed in the watershed than diazinon. In comparing Figure 11 to Figure 7 (land use), one can see a correlation of the heavier areas of chlorpyrifos use with citrus crops in the northwestern portion of the watershed and truck crops in the lower part of the watershed. These categories of crops represent the bulk of agricultural chlorpyrifos use as presented in Table 40. The areas of relatively heavier use lie primarily along Revolon Slough (Reach 4), Beardsley Channel (Reach 5), Calleguas Creek (Reaches 2 and 3), and the Arroyo Las Posas (Reach 6). Additionally, there are pockets of relatively higher use along the Conejo Reaches (9A, 9B, and 11).

5.3.3.1 Agricultural Pesticide Application

Diazinon and chlorpyrifos are applied to a wide variety of crops. Table 39 and Table 40 present the top 15 crops, in pounds of diazinon and chlorpyrifos applied, between 1998 and 2003. These 15 crops account for 95 percent of diazinon and 99 percent of chlorpyrifos agricultural use during this period. Between 1998 and 2002, 96 percent of chlorpyrifos was applied by ground-based equipment, four percent was applied aerially, and less than one percent was applied through other methods (injection, chemigation, etc.). During this same period, approximately 94 percent of diazinon was applied by ground-based equipment, six percent was applied aerially, and less than one percent was applied through other methods (injection, chemigation, etc.). Table 41 present the pounds of diazinon and chlorpyrifos applied through the various categories of applications. All crop types received either just ground-based applications or ground-based and aerial applications, with only one instance of an aerial only application to mustard in 1998.

Table 41. Diazinon and Chlorpyrifos Applied Through the Various Application Methods from 1998 – 2002

Constituent	Pounds Active Ingredient Applied				Percentage of Application		
	Ground	Aerial	Other	Total	Ground	Aerial	Other
Diazinon	31,488	1916	202	33,606	93.7%	5.7%	0.6%
Chlorpyrifos	171,561	7,120	281	78,962	95.9%	3.9%	0.2%

Ground – Ground-based equipment applied   Aerial – Aerially applied
Other – Other application methods may include (injection, chemigation, etc.)

5.3.3.2 Agricultural Runoff Data

Data from all agricultural runoff sites that discharge directly to defined reaches in the CCW are aggregated to determine characteristic concentrations of chlorpyrifos and diazinon in return flows. These sites carry return flows from mixed agricultural sites representing a variety of crops. Samples were collected during both dry and wet weather. Table 42 presents summary statistics based on the available chlorpyrifos and diazinon data sampled from runoff dominated by agricultural land use activities. Figure 12 and Figure 13 present time series plots of the chlorpyrifos and diazinon agricultural runoff data, respectively. Current data are limited but fall within the range of what was observed historically. This is relatively consistent with what could be expected based on PUR data. As mentioned previously, chlorpyrifos use has not changed significantly and diazinon use has declined relatively slowly (except 1998-1999) over the time frame examined.

Table 42. Chlorpyrifos and Diazinon Agricultural Runoff Flows Data Summary

Constituent	Number of Samples	Number Detected	% Detected	Mean (ug/L)	Median (ug/L)	Range of Detection Limits (ug/L)	Maximum Detected Value (ug/L)
Chlorpyrifos	75	28	37.3%	0.179	0.050	0.044 – 2	3.3
Diazinon	66	15	22.7%	0.040	0.025	0.005 – 0.5	0.17

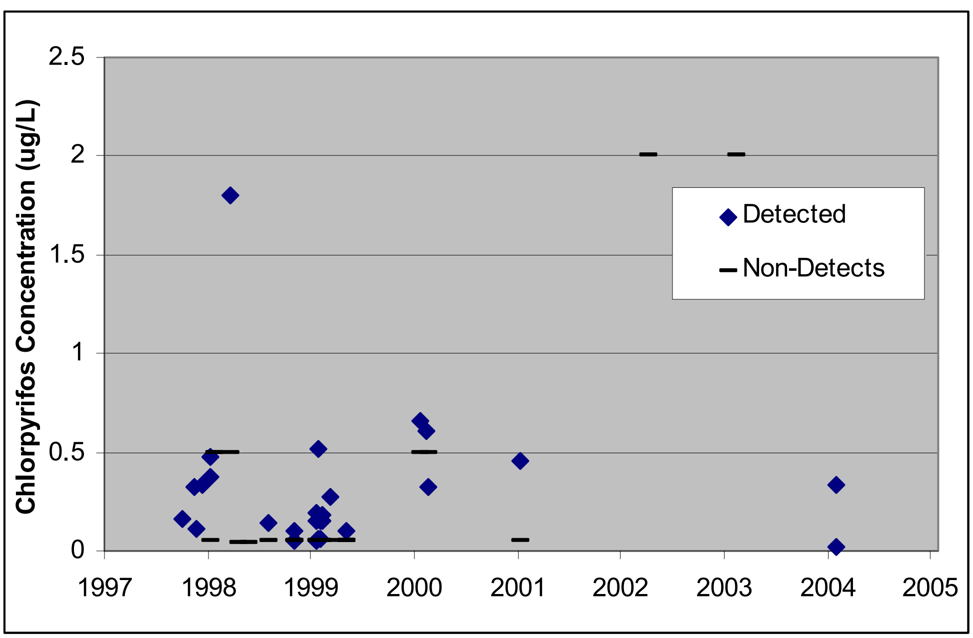


Figure 12. Time series plot of chlorpyrifos data from agricultural discharge monitoring sites.

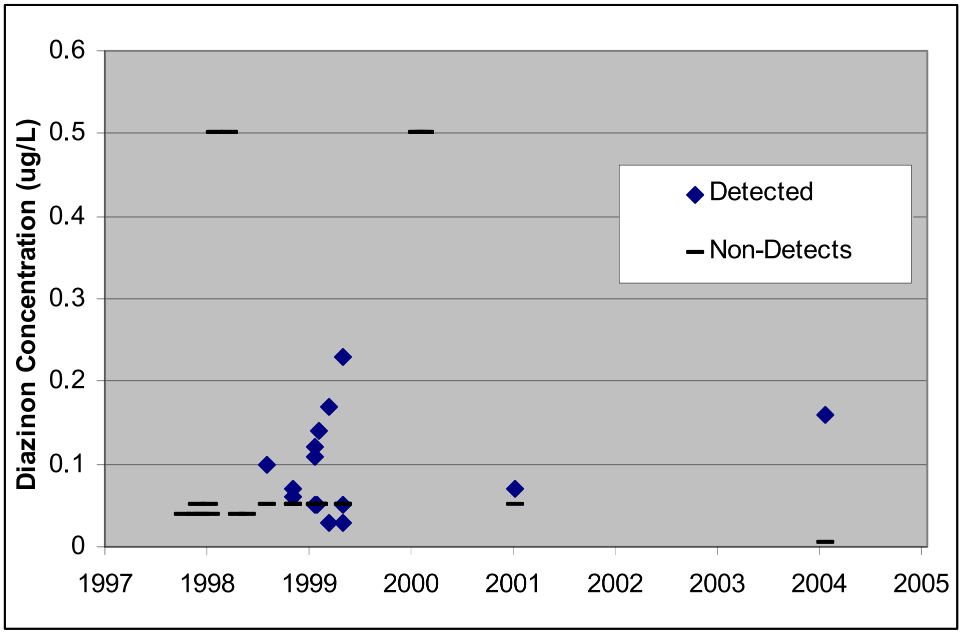


Figure 13. Time series plot of diazinon data from agricultural discharge monitoring sites.

The concentration log-normal probability distributions calculated via the ROS method for chlorpyrifos and diazinon are plotted in Figure 14. Superimposed on the figure are the 95th probability level and the probabilities associated with the in-stream water quality criteria. Less than a quarter of the chlorpyrifos samples are currently estimated to fall below the chronic criteria of 0.014 ug/L, and slightly more than one-third are below the acute criteria of 0.025 ug/L. It is estimated that 90% of the diazinon values are below the 0.1 ug/L acute and chronic water quality criteria. Fill-in values are plotted as horizontal lines on Figure 14 for samples where the pesticides were non-detected to illustrate the number of samples with high detection levels. The probability density functions (PDF) for chlorpyrifos and diazinon are superimposed on the respective plots. The PDFs plots as normal "bell" curves because the concentration scale is plotted as a log-scale. Standard deviate (or z-score, z, etc) is the number of standard deviations from the median, so z=0 is the median or 50%. The distribution regression line from the ROS method allows calculation of expected concentration given a probability, and is exactly equivalent to matching the probability of the PDF to a concentration. In Figure 14, the criteria are specifically called out in terms of standard deviate, probability, and plotting on the PDF. Both chlorpyrifos and diazinon plots are set to identical scales allowing comparison of graphical features. Visual inspection reveals that chlorpyrifos has a higher mean and is more variable because the intercept of the chlorpyrifos distribution line is higher than the diazinon line and the slope of the chlorpyrifos distribution line is greater than the diazinon distribution line. The PDFs highlight the difference in the chlorpyrifos and diazinon data sets as the chlorpyrifos PDF is more spread-out indicating higher variability. See the Current Conditions section for a more detailed discussion of the ROS method.

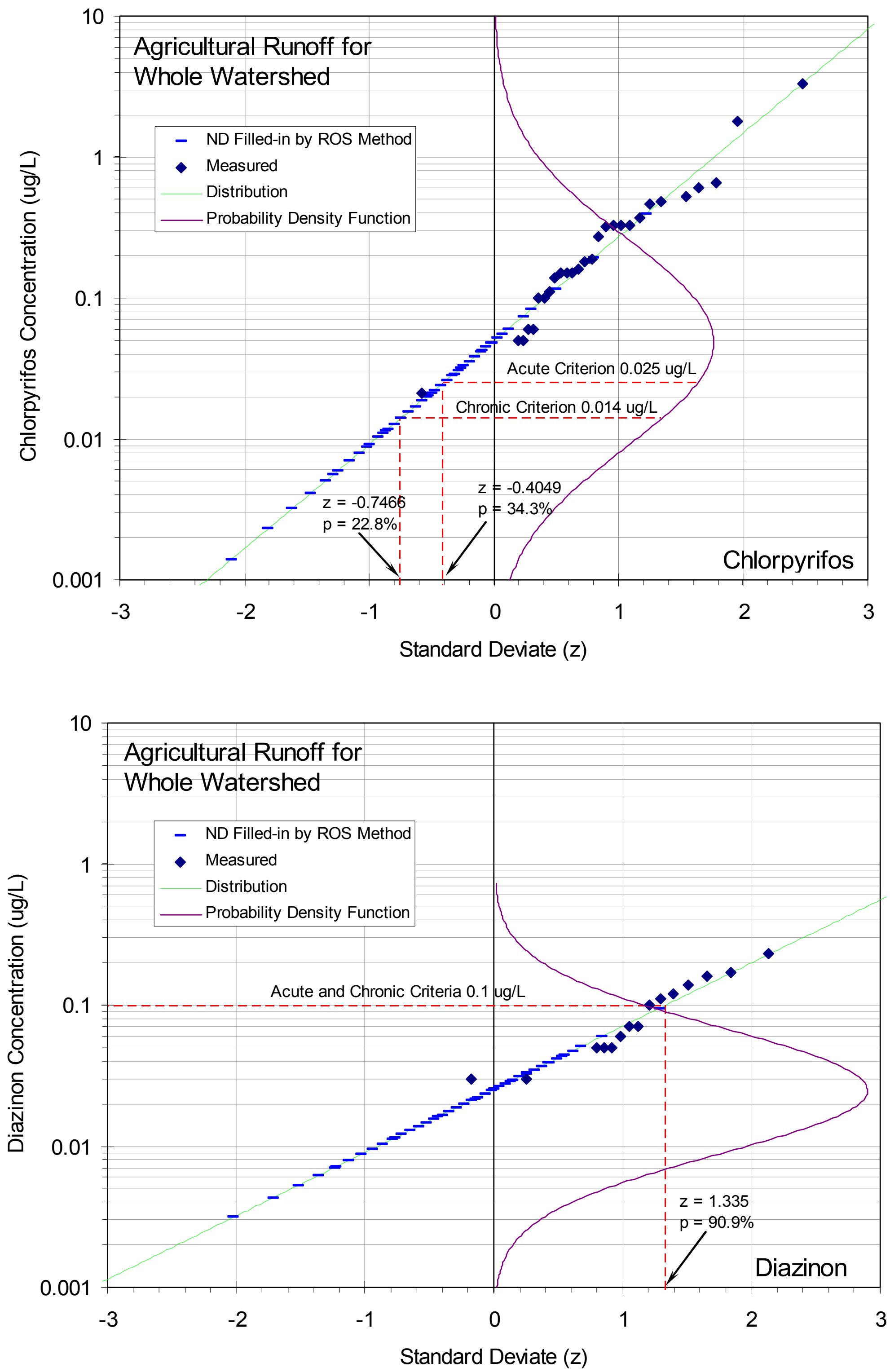


Figure 14. Agricultural runoff chlorpyrifos and diazinon concentration log-normal probability distributions. ND filled-in values represent the calculated values of the ND data via the ROS method and do not correspond to physical measurements. Both plots use identical scales.

5.3.3.3 Agricultural Application Compared to In-stream Concentration

A comparison between reported agricultural applications of chlorpyrifos and diazinon to in-stream water quality was conducted. The comparison was conducted to determine if there is a correlation between in-stream water quality and the timing of agriculture applications of chlorpyrifos and diazinon. PUR application data was aggregated by month by subwatershed and in-stream water quality data was averaged by month by subwatershed. It was presumed the mostly likely time a correlation would exist would be during the timing of heaviest applications. The heaviest use of chlorpyrifos occurs between August and November (approximately 79 percent), which coincides with the primary application of this pesticide to lemons. The heaviest use of diazinon occurs between April and May (approximately 66 percent), which coincides with the majority of applications to beans. Figure 15 present the results of this comparison for the Revolon Slough Subwatershed. No correlation between application and in-stream water quality is readably observable. In-stream water quality data are limited and were not available for all months. Additional data collected through the monitoring program presented in the Implementation Plan section will provide a more robust data set with which to conduct this comparison in the future.

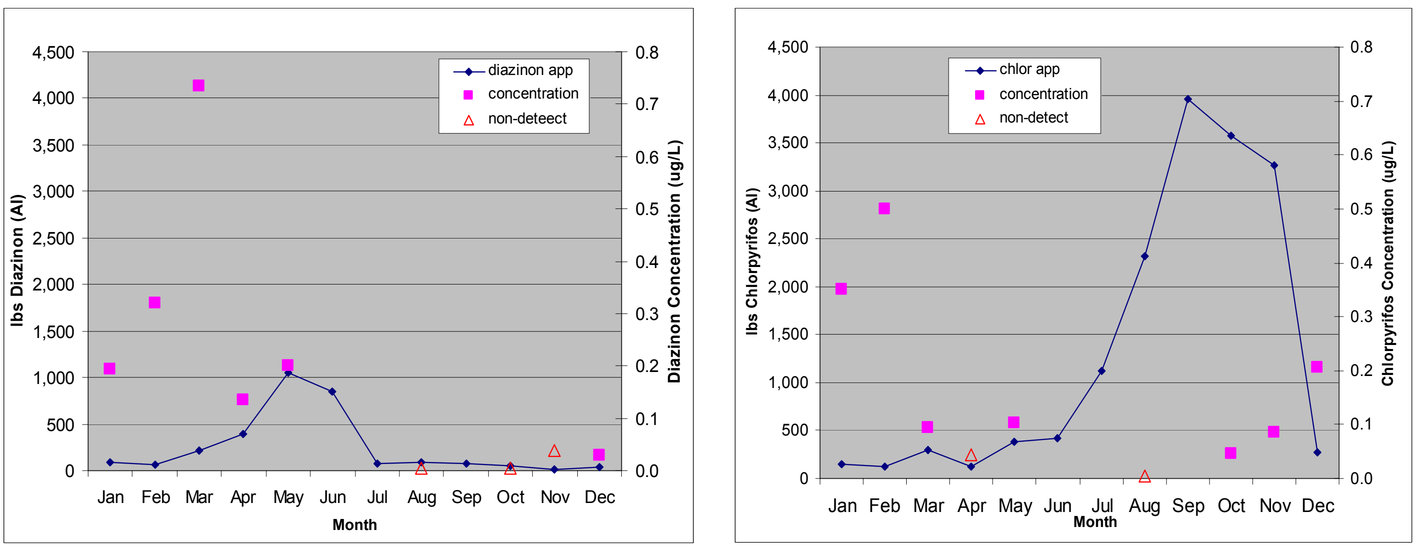


Figure 15. Average monthly application of chlorpyrifos and diazinon compared to in-stream water quality.

5.3.4 Urban Use

Certain non-agricultural uses of pesticides must be reported to the County and are subsequently included in PURs. The non-agricultural uses for chlorpyrifos and diazinon reported in the PURs were considered urban uses. Between 1998 and 2003 reported urban uses for diazinon and/or chlorpyrifos included structural pest control, landscape maintenance (parks, golf courses, and cemeteries), rights of way maintenance, vertebrate control, and public health pest control. The one application of diazinon for vertebrate control (~ 0.7 pounds) and the one application of chlorpyrifos for public health pest control (~ 1.7 pounds) reported between 1998 and 2003 were considered insignificant and were not incorporated in this analysis. Reported urban use data do not contain information on the location of pesticide application except for the county in which the application is made. As there is no way to reference reported urban uses, the location of these applications in Ventura County could not be determined. To address this issue, the amount of pesticides used for urban uses were multiplied by the percentage of urban area in Ventura

County located in the CCW. Based on the California Department of Water Resources' 2000 land use layer for Ventura County, approximately 51.2 percent of the urban area in Ventura County is located in the CCW. In 2003, an estimated 501 pounds of diazinon and 643 pounds of chlorpyrifos were reported used for urban purposes in the CCW, representing 51.2 percent of total reported urban uses in Ventura County.

Figure 16 and Figure 17 present estimated annual reported diazinon and chlorpyrifos urban uses in the CCW from 1998 through 2003. As indicated in Figure 16, the total annual use of diazinon for reported urban uses has declined by 80 percent between 1998 and 2003. The largest annual decrease in overall use occurred between 2001 and 2002 (53 percent) and 2002 and 2003 (60 percent). As indicated in Figure 17, the total annual reported urban use of chlorpyrifos has declined by 72 percent between 1998 and 2003, with the largest decrease occurring between 2000 and 2001 (79 percent). The decreases in reported urban uses of chlorpyrifos and diazinon could be the result of the phase out of most urban uses. Structural pest control is by the far the largest reported urban use for both diazinon and chlorpyrifos, although annual use for structural pest control is declining and will be completely banned on December 31, 2005. Concern has been raised with regard to the contribution of diazinon and chlorpyrifos from golf courses. In reviewing PUR data, the 15 golf courses located in the CCW did not report use of notable amounts of these constituents between 1998 and 2003.

Figure 16 and Figure 17 also present reported monthly diazinon and chlorpyrifos urban uses in the CCW from 1998 through 2003. Unlike agriculture, there is no clear trend in the monthly data for urban uses of diazinon or chlorpyrifos. In looking at historical monthly averages there does not seem to be a month or series of months that dominate total urban uses. However, urban use of diazinon and chlorpyrifos are unlikely to be a long-term source to the CCW as neither of these pesticides will be sold for non-agricultural uses as of December 31, 2005.

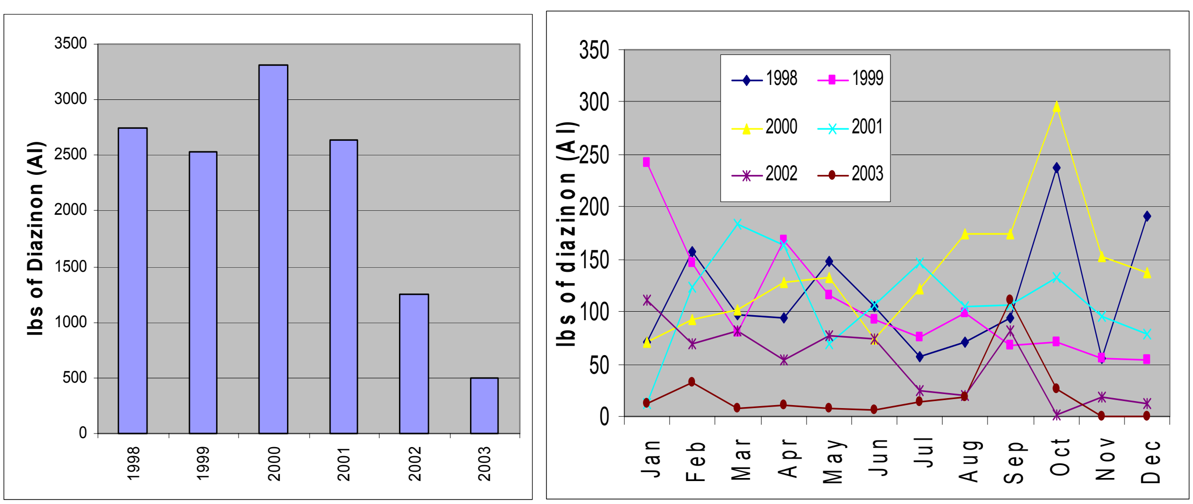
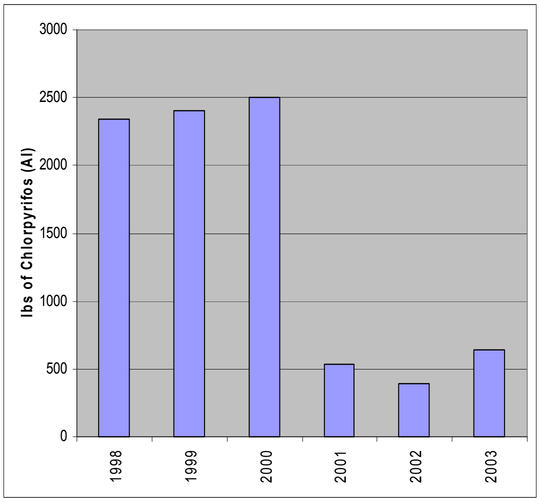


Figure 16. Reported diazinon urban use in CCW by year and month from 1998 – 2003 (DPR).



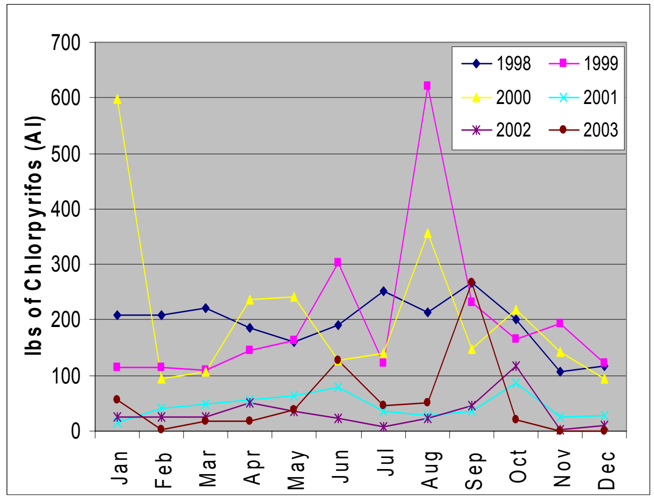


Figure 17. Reported chlorpyrifos urban use in CCW by year and month from 1998 – 2003 (DPR).

5.3.4.1 Unreported Use

Uses of pesticides excluded from reporting requirements include industrial, institutional, and home and garden pesticide uses. These uses are collectively referred to as "unreported uses". An estimate of unreported diazinon and chlorpyrifos use in the CCW was made based on the Survey of Residential Pesticide Use and Sales in San Diego Creek Watershed of Orange County California (Wilen, 2001). The survey, conducted between August and October 2000, estimated the amount of diazinon and chlorpyrifos sold for unreported use in the San Diego Creek watershed. Assuming all sales resulted in the use of the pesticide, unreported use for the CCW was estimated by multiplying the ratio of populations in the San Diego Creek watershed and the CCW. An analysis of the 2000 census and population data for the CCW yielded a population estimate of 334,000, approximately 42 percent of the San Diego Creek watershed (797,000). Based on relative populations and the results of the Wilen survey, an estimated 1,063 pounds of chlorpyrifos and 15,123 pounds of diazinon are used for unreported uses in an urban environment on an annual basis. Although this approach creates highly uncertain estimates, it does provide some level of understanding of the possible quantities of these pesticides available for unreported uses in an urban environment over the past few years. However, unreported urban use of diazinon and chlorpyrifos are unlikely to be a long-term source to the CCW as neither of these pesticides will be sold for unreported uses as of January 1, 2004. Reported urban uses of chlorpyrifos can still occur until December 31, 2005.

5.3.4.2 Estimated Time Frame/Reductions as a Result of Phase Out

As discussed previously, unreported urban uses of chlorpyrifos and diazinon were estimated at 1,063 pounds and 15,123 pounds, respectively. If it is assumed that temporal reduction of unreported use follows the same pattern as reported urban uses as shown in Figure 16 and Figure 17, then unreported use of diazinon and chlorpyrifos between 2000 and 2003 can be estimated as shown in Table 43.

Table 43. Estimated Annual Unreported Use of Diazinon and Chlorpyrifos (pounds AI)

Constituent	Year			
	2000	2001	2002	2003
Diazinon	15,123	12,087	5,724	2,290
Chlorpyrifos	1,063	228	166	273

Pesticide products containing diazinon come with a recommendation to apply between 0.000066 lb diazinon/sq.ft. and 0.0001 lb diazinon/sq.ft.[2] Using an average application rate of 0.000083 lb diazinon/sq.ft., the area that would be covered by application of the diazinon quantities shown in Table 43 are shown in Table 44. Similarly, pesticide products containing chlorpyrifos come with a recommendation to apply between 0.000025 lb chorpyrifos/sq.ft. and 0.00005 lb chlorpyrifos /sq.ft.[3] Using an average application rate of 0.000038 lb chlorpyrifos/sq.ft., the area that would be covered by application of the chlorpyrifos quantities shown in Table 43 are shown in Table 44.

Table 44. Area Covered Based on Diazinon and Chlorpyrifos Unreported Use Estimates

	Year			
	2000	**2001**	**2002**	**2003**
Quantity diazinon used (pounds AI)	15,123	12,087	5,724	2,290
Area in acres covered using 0.000083 lb diazinon /sq.ft.	4,180	3,341	1,582	633
Quantity chlorpyrifos used (pounds AI)	1,063	228	166	273
Area in acres covered using 0.000038 lb chlorpyrifos /sq.ft.	651	140	102	167
Total acreage covered by both pesticides	4,831	3,481	1,684	800

Table 37 shows a combined acreage for residential, commercial and industrial land use (i.e., sites of unreported pesticide uses) in the CCW of 33,700 acres. The maximum area covered by unreported use of diazinon and chlorpyrifos is 14 percent of the area in the CCW where unreported use is likely to occur. The previously mentioned Survey of Residential Pesticide Use and Sales in San Diego Creek Watershed (Wilen, 2001) gathered information regarding storage of pest control products. When asked how many pest control products were stored in their home, nine percent of survey respondents said they had no pesticides and 81 percent indicated they had between one and five pest control products. In addition, seven percent of respondents had between six and 10 products and three percent of respondents had more than 10 pest control products. When asked how long they stored pest control products, five percent of those who had pest control products indicated that the oldest product was less than one year old while 71 percent indicated that the oldest pest control product was between one and three years old. Based on these responses, approximately 79 percent of residents would be expected to either have no pesticides or store pesticides for less than three years. Therefore, it is likely that most of the pesticides used for unreported uses would be used up within three years of the date that retail sales are discontinued. This would correspond to urban sources of diazinon being significantly reduced by the end of 2007. Chlorpyrifos retail sales to non-licensed urban users ended in 2001; however, structural pest control applications were permitted until December 31, 2005. This would correspond to urban sources of chlorpyrifos being significantly reduced by the end of 2005. However, as 21 percent of residents indicated that the oldest pest control product was stored longer than three years, urban uses of chlorpyrifos and diazinon will likely continue past 2005 and 2007, respectively.

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[2] Label instructions for Diazinon Insecticide 25% Spray Concentrate, 5% Diazinon Granules, Ortho Diazinon Ultra Insect Spray. http://www.southernag.com/labels.htm; http://www.ortho.com/ (product guide)

[3] Label instructions for Dursban 2.5%Granular Insecticide, Dursban 1% Granular Insecticed, and Dursban Ant & Turf Granules. http://www.southernag.com/labels.htm

5.3.4.3 Urban Runoff Data

Urban runoff concentrations are calculated by combining runoff data from residential, commercial, and industrial land uses as well as mixed urban land uses. Chlorpyrifos and diazinon data for urban runoff were collected at selected characterization sites. All of the urban runoff sites are located in Ventura County; however, not all of the sites are located in the CCW. The underlying assumption is that the selected characterization sites are representative of all urban sites in the CCW. Samples were collected during both dry and wet weather. Table 45 presents the available chlorpyrifos and diazinon data sampled from runoff dominated by urban land use activities. Figure 18 and Figure 19 present time series plots of the chlorpyrifos and diazinon urban runoff data, respectively. Figure 18 shows that detected data for chlorpyrifos are limited, with only one recent detected value. This single detected data point falls within the range of what was observed historically. As presented in Figure 19, there are considerably more detected diazinon data points. The clustering of the more recent detected data is lower than historical data, with the bulk of the recent data below 0.1 ug/L and the bulk of the historic data greater than 0.3 ug/L. The lack of recent detected chlorpyrifos data and the seeming downward trend of detected diazinon data are consistent with declining urban uses.

Table 45. Chlorpyrifos and Diazinon Urban Runoff Flows Data Summary

Constituent	n	Number Detected	% Detected	Mean (ug/L)	Median (ug/L)	Range of Detection Limits (ug/L)	Maximum Detected Value (ug/L)
Chlorpyrifos	47	5	10.6%	NA	NA	0.005 – 0.5	0.45
Diazinon	50	27	54.0%	0.098	0.036	0.005 – 1.3	0.5

NA Insufficient detected data to determine mean.

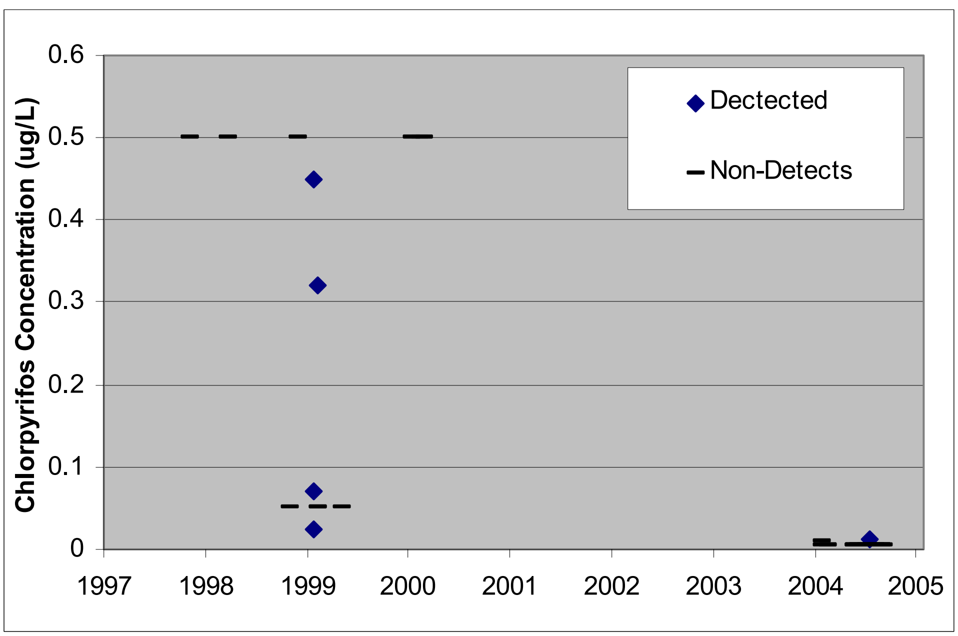


Figure 18. Time series plot of chlorpyrifos data from urban discharge monitoring sites.

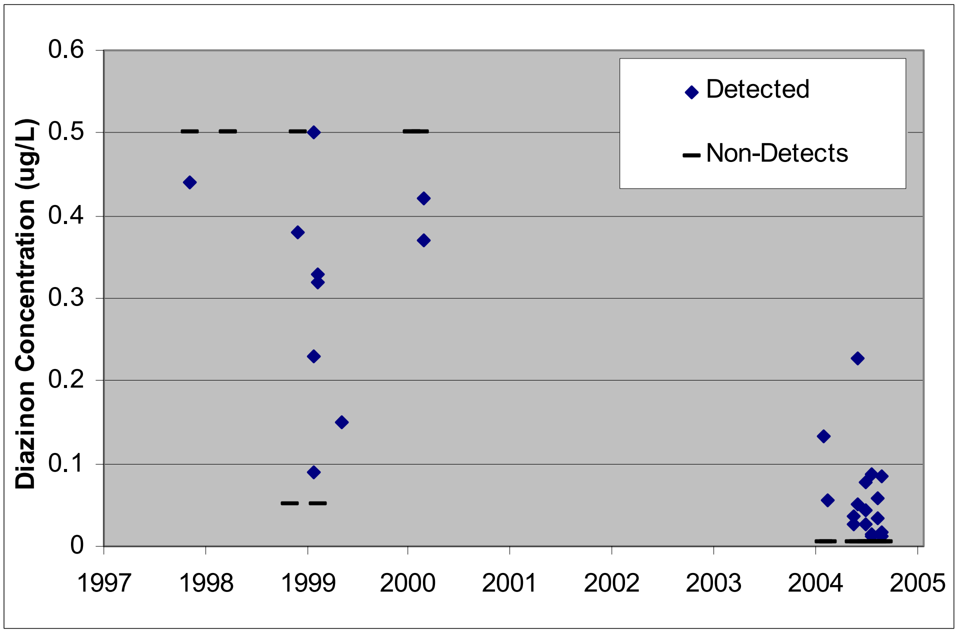
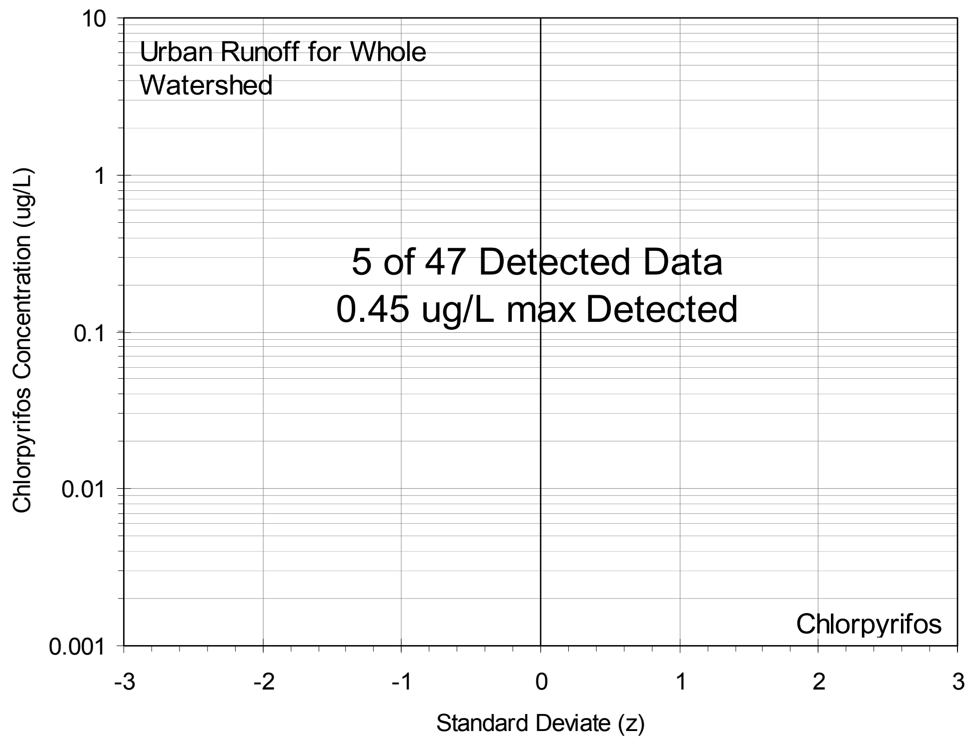


Figure 19. Time series plot of diazinon data from urban discharge monitoring sites.

Probability plots of available chlorpyrifos and diazinon data are presented in Figure 20. Chlorpyrifos was detected in only five of 26 samples, so a distribution plot could not be calculated. The probability plot of diazinon reveals the concentrations in urban runoff exceed receiving water quality objectives approximately 60% of the time. Likely due to the phase-out of the sale of chlorpyrifos and diazinon, there has been a decrease in urban runoff concentrations of these constituents, however all urban runoff data are included in the analysis as a conservative measure to prevent underestimation of the urban runoff contribution to receiving water load.



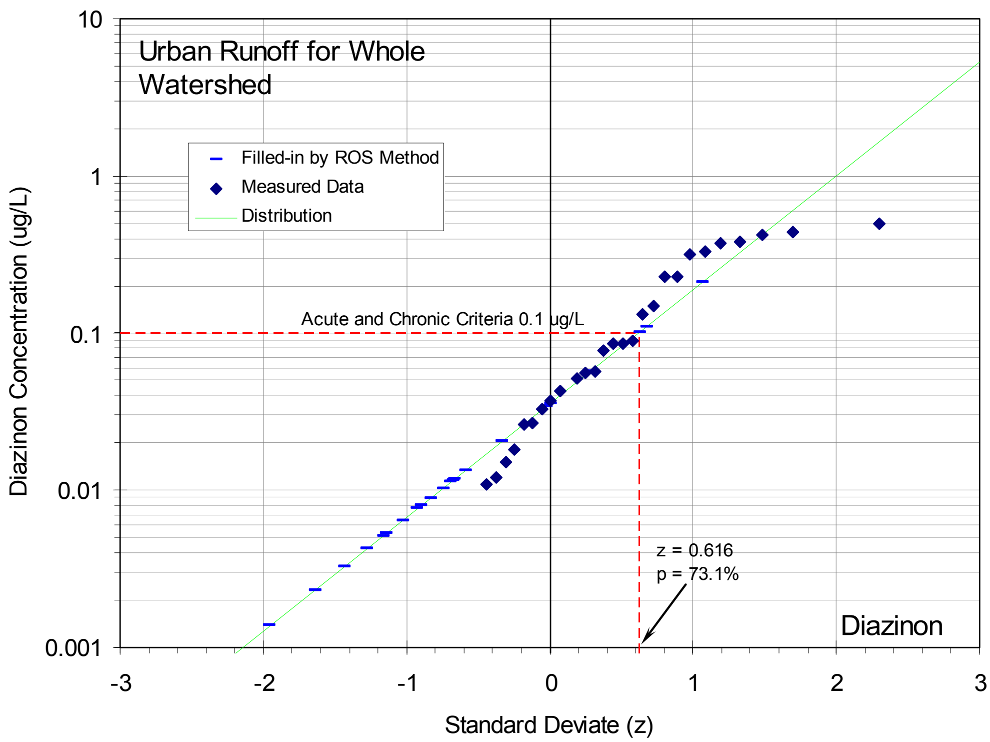


Figure 20. Distributions of chlorpyrifos and diazinon concentrations sampled from urban runoff. Data from all urban characterization sites combined. ND filled-in values represent the calculated estimate of the non-detected values via the ROS method and do not correspond to physical measurements.

5.3.5 Comparison of Agricultural, Urban, and Unreported Uses

Figure 21 presents a comparison of the total reported agricultural and urban uses of chlorpyrifos and diazinon. Agricultural uses account for the majority of use for both pesticides. For chlorpyrifos used between 1998 and 2003 in the CCW, agricultural uses represented between 93 and 99 percent of reported uses annually. For diazinon, agricultural uses represented between 66 and 91 percent of reported uses annually during the same period.

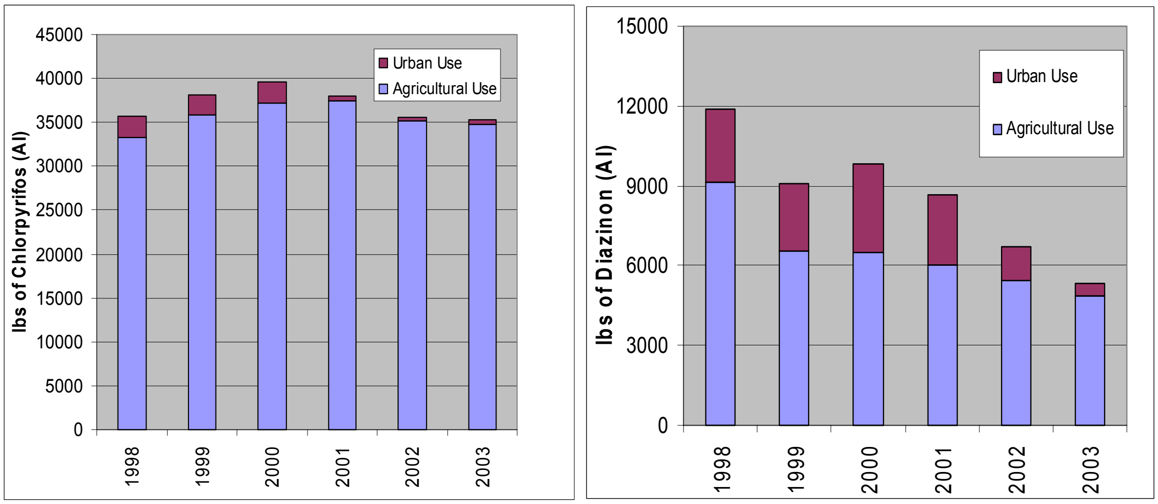


Figure 21. Comparison of reported agricultural and urban uses in CCW by year from 1998 – 2003 (DPR).

Figure 22 presents a comparison of the total reported uses (agricultural and urban) and estimated unreported uses of chlorpyrifos and diazinon. Estimated unreported uses of chlorpyrifos are relatively low in comparison to reported uses, consistent with the end of retail sales to non-licensed urban users in 2001. Estimated unreported uses of diazinon are relatively high in comparison to reported uses, although the observed percentage of total use reduces significantly over the time period examined.

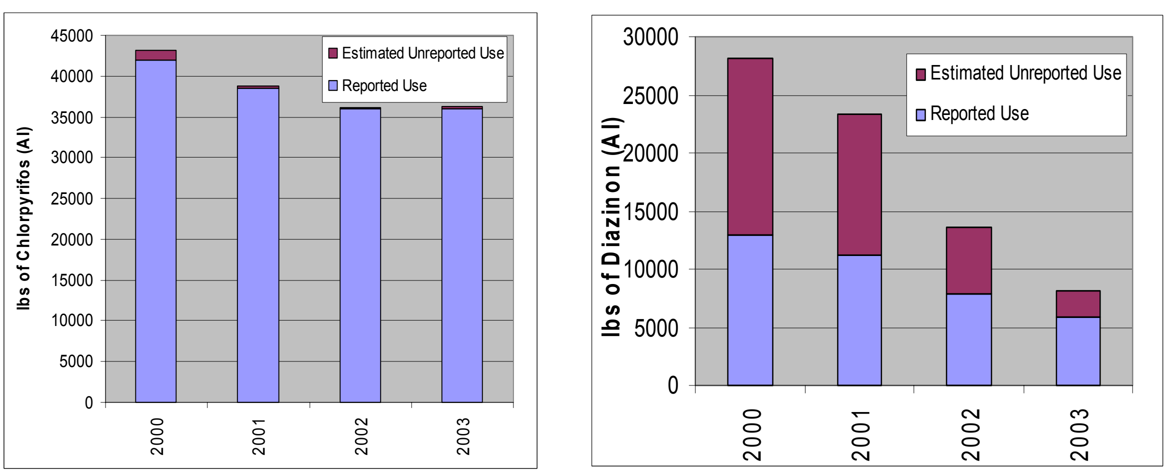


Figure 22. Comparison of reported uses (agricultural and urban) to estimated unreported uses in CCW by year from 2000 – 2003.

5.3.6 Publicly Owned Treatment Works

Publicly owned treatment works (POTWs) receive inputs of diazinon and chlorpyrifos via infiltration and inflow from stormwater runoff within their service areas, and may also receive inputs of such pesticides from washing of fruits, vegetables, and clothes and from the improper disposal of pesticides. All available data for chlorpyrifos and diazinon in POTW effluent in the CCW are listed in Table 46. It should be noted, the only available chlorpyrifos and diazinon data characterizing POTW effluent were collected between July 1998 and May 1999. Reported use, and likely unreported use, of these pesticides in urban environments have decreased since these data were collected. In turn, it is likely the loads and/or concentrations of these pesticides in POTW effluent have decreased. However, there is no clear way to adjust the available data to estimate current concentrations.

Table 46. Chlorpyrifos and Diazinon Detected Values for POTW Discharge in the CCW.

POTW	Chlorpyrifos				Diazinon			
	Number of Samples	Number Detected	% Detected	Detected Values (ug/L)	Number of Samples	Number Detected	% Detected	Detected Values (ug/L)
Simi Valley	4	0	0%	–	4	3	75%	0.25 0.25 0.14
Moorpark[1]	2	0	0%	–	3	2	67%	0.11 0.17
Olsen Road [2]	4	1	25%	0.03	4	0	0%	–
Hill Canyon	4	0	0%	–	4	0	0%	–
Camarillo	4	0	0%	–	4	2	50%	0.09 0.25
Camrosa[1]	0	0	–	–	0	0	0%	–

1 In general, Moorpark and Camrosa do not discharge to surface waters of the United States as these plants are designed to have zero discharge expect during abnormally wet years.
2 Olsen Rd decommissioned in 2002, all flow currently diverted to Hill Canyon.

5.3.7 Groundwater

Groundwater exfiltration and groundwater dewatering discharges are considered under the general heading of groundwater inputs to the CCW. Currently, the only dewatering wells included in this analysis are located in the Simi Valley area of the watershed. The groundwater flows in the Simi Valley are largely due to continuous pumping to lower the groundwater table. From a source perspective, the dewatering well discharges affect the CCW system in an equivalent manner to the natural exfiltration of groundwater. Four dewatering well discharge water samples did not reveal the presence of chlorpyrifos or diazinon in the Arroyo Simi groundwater. There is little information available on chlorpyrifos or diazinon in the groundwater in other areas of the CCW. Given that diazinon is moderately soluble in water there is the potential for this pesticide to infiltrate into groundwater, however, there is no data that indicates this is occurring in the watershed. Conversely, chlorpyrifos is relatively insoluble in water and is less likely to infiltrate into groundwater.

5.3.8 Atmospheric and Aerial Deposition

Atmospheric and aerial deposition includes wet and dry deposition components. Rainfall can associate with diazinon and chlorpyrifos due to volatilization of these pesticides in the atmosphere. Ambient air and wet-deposition monitoring has occurred for both chlorpyrifos and diazinon in other areas. Monitoring of chlorpyrifos in the Central Valley of California indicated atmospheric transport was occurring as far as the

Sierra Nevada Mountains (80 – 100 miles). Zabik and Seiber (1993) found that concentrations of chlorpyrifos in air decreased with distance from the source area with a maximum concentration of 6.5 ng/m^3 recorded in the valley. As presented in the Toxicology Profile for Diazinon (USDHHS, 1996), multiple studies have reported the presence of diazinon in atmospheric samples. In a sample collected near fruit and nut orchards in Parlier, California, reported mean concentrations of diazinon measured 76.8 ng/m^3 (Cited in USDHHS, 1996). In an experiment conducted by Alameda County (2001), diazinon solution was applied around the perimeter of a building. During ensuing rain events, occurring up to three months after initial application, diazinon was measured in all of the rainwater samples ranging from 3 to 15,000 ng/L. Application methods can vary based on crop type, applicator preference, etc., affecting volatilization rates and ultimately atmospheric and aerial deposition.

The rates of atmospheric and aerial deposition of chlorpyrifos and diazinon in urban areas have not been measured. Estimates have been determined using ambient concentrations and assumed deposition rates, but the determined rates carry a high degree of uncertainty and may be unrealistic (Ross, 2002). A study conducted by Dow AgroSciences (1998) at Orestimba Creek around agricultural sites in Stanislaus County involved surface water monitoring for a year. The researchers found that some concentration peaks detected for several OP pesticides could be associated with specific pesticide application events, and that the most probable transport process could be determined. For chlorpyrifos, nine of 13 attributable concentration peaks were a result of drift from the application site. For diazinon, five of 14 attributable peaks were a result of drift from the application site (SRWP, 2000).

Majewski and Baston (2002) conducted ambient air quality monitoring for OP pesticides in the Sacramento urban area and nearby agricultural areas during the period 1996-1997. Of 17 pesticides monitored during the study, chlorpyrifos, diazinon, and trifluralin accounted for 24 percent of the agricultural and 76 percent of the non-agricultural/urban pesticides used during the two-year study period.

The Southern California Coastal Water Research Project (SCCWRP) is beginning a study to determine the impact of atmospheric deposition of pesticides transported from sources within the airshed to waterbodies of interest in selected regions of Southern California. Results from the study may provide additional information to quantify pesticide deposition rates in urban areas.

The above studies do not provide enough information to determine the local deposition rate of chlorpyrifos and diazinon. Monitoring of wet and dry deposition rates of pesticides would provide the clearest information to incorporate the atmospheric contribution to the runoff water quality.

Wet deposition over agricultural and urban areas is implicitly included in the runoff measurements. Direct deposition to the waterways in the CCW is negligible in comparison to the deposition component of stormwater runoff as the water surface area for the entire watershed is less than 1% of the total watershed surface area. An identical approach for chlorpyrifos and diazinon has been adopted in the Newport Bay Toxics TMDL (USEPA, 2002b).

5.3.9 Imported Water

Imported water is a potential source of diazinon and chlorpyrifos to the watershed. Imported water is used for agriculture and urban irrigation, washing cars, and other purposes that result in runoff into storm drains or infiltration into groundwater. Drinking water and irrigation water are imported to the watershed from the State Water Project and the Freeman Diversion, respectively. The State Water Project pumps water from the San Francisco Bay Delta, which originates in northern and central California, including the Central Valley, an area of intense agricultural activity. Water suppliers regularly analyze their water for a variety of pollutants. As there is no evidence to the contrary, it is assumed there are no detectable levels of chlorpyrifos or diazinon in imported.

5.3.10 Native Space Runoff

Runoff from native areas of vacant, undeveloped, open space was considered “Native Space”. However, there are no data currently available describing chlorpyrifos or diazinon concentrations in the native runoff in the CCW. A zero contribution of chlorpyrifos and diazinon from open space has been adopted in the Newport Bay TMDL (USEPA 2002b), however, a small but non-zero load from Native Space is incorporated into the TTMBM.

Summary

Figure 23 presents the relative magnitude of identified sources of chlorpyrifos to CCW during dry and wet weather conditions. Figure 24 presents the relative magnitude of identified sources of diazinon to CCW during dry and wet weather conditions. Figure 25 presents relative chlorpyrifos and diazinon loads based on season (wet season defined as October through April). Figure 26 presents relative chlorpyrifos and diazinon loads based on weather (i.e in-stream flowrate greater than the 86th percentile is considered wet weather). Agricultural and urban uses are the largest sources of these pesticides in the watershed. However, urban use of diazinon and chlorpyrifos are unlikely to be a long-term source to the CCW as neither of these pesticides will be sold for non-agricultural uses as of December 31, 2005. As a result, the proportion of the loading from urban sources will likely decrease some time after December 2005.

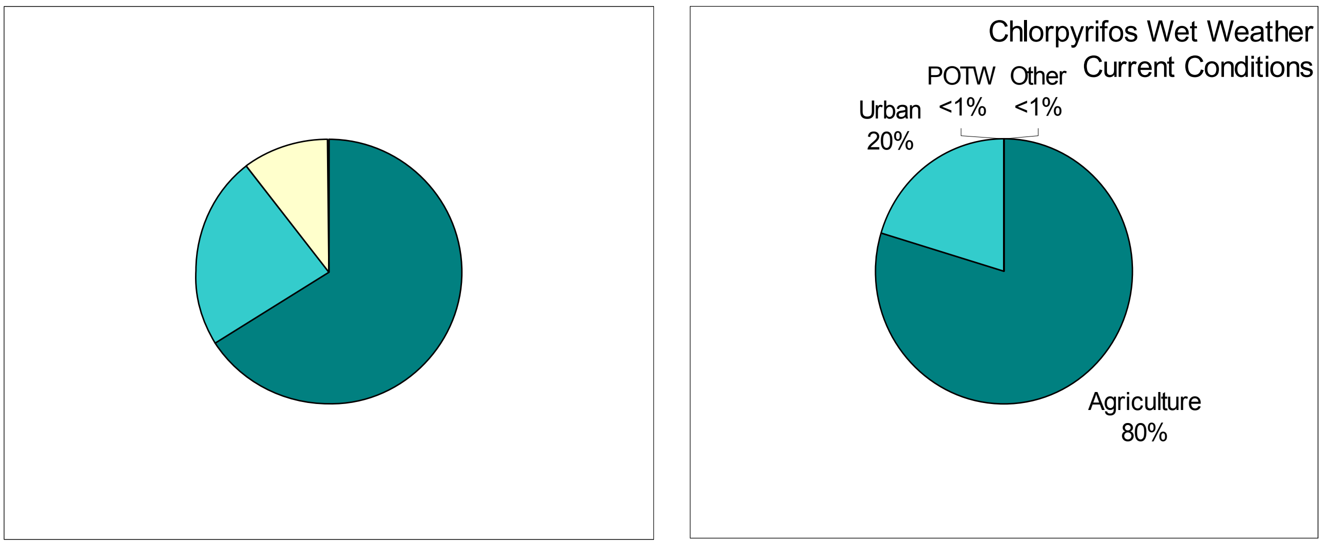


Figure 23. Chlorpyrifos loading from various land uses for entire CCW.

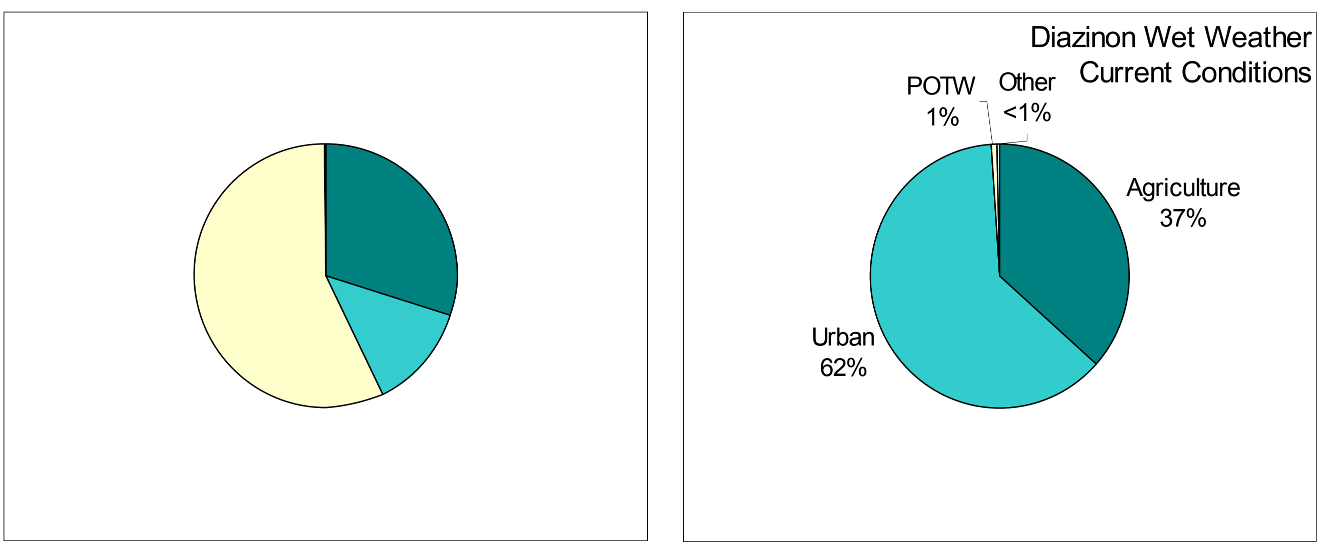


Figure 24. Diazinon loading from various land uses for entire CCW.

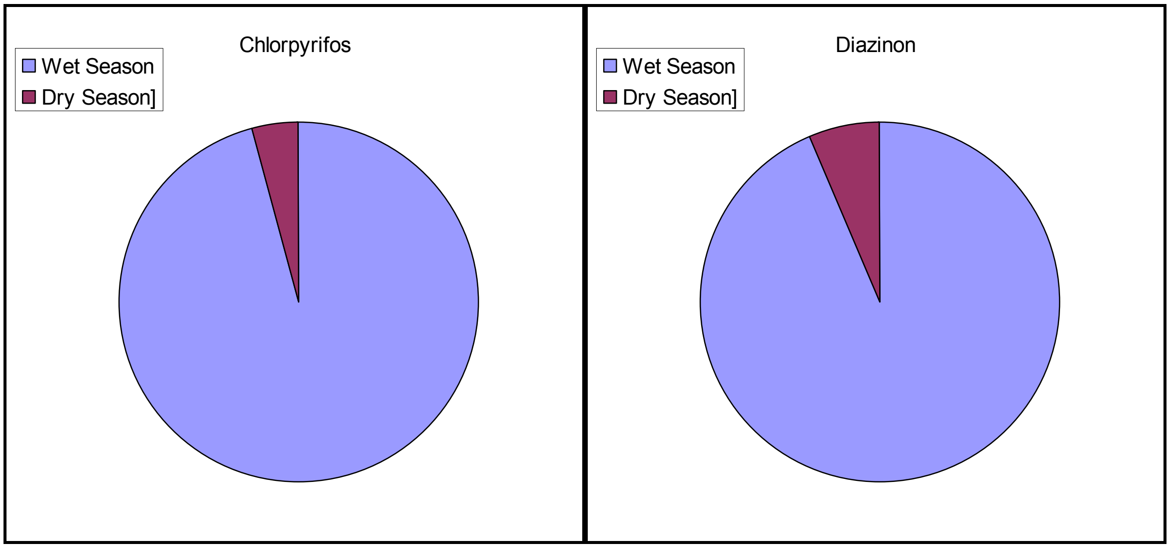


Figure 25. Relative chlorpyrifos and diazinon loads based on season. Where the wet season is defined as October through April.

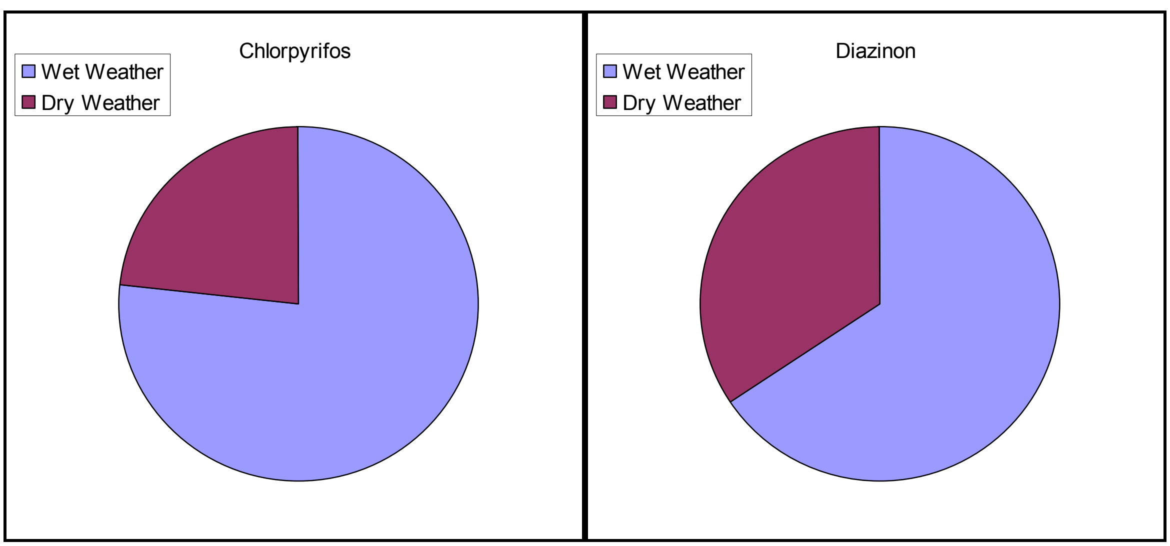


Figure 26. Relative chlorpyrifos and diazinon loads based on weather (i.e in-stream flowrate greater than the 86th percentile is considered wet weather).

6 Linkage Analysis

A brief review of the degradation processes and modeling of chlorpyrifos and diazinon in the CCW is presented in the Linkage Analysis section. Modeling was performed to provide decision support to understand the source and sinks of constituents identified as toxicological agents in the CCW, and not toxicity *per se*. The model focused on chlorpyrifos and diazinon as these two pesticides are 1) identified in the Current Conditions section as a likely cause of toxicity within the CCW; and, 2) these constituents are on the 303(d) list for reaches in the CCW. If additional constituents are identified as contributing to water and/or sediment toxicity and these constituents are not appropriately addressed by other TMDLs, a linkage analysis addressing these constituents may need to be developed. The modeling approach reflects the high degree of uncertainty in current conditions and the potential impacts of actions intended to affect those conditions. Numerous simplifying assumptions are required to address uncertainties at every step in the linkage between sources and impacts to beneficial uses. The assumptions cover uses and application rates; current sources and loading rates; and streambed and water column concentrations. A more detailed description of the model and the linkage analysis is provided in Attachment A.

6.1 *Model Selection*

Model selection criteria were developed to compare and evaluate potential numerical models to assess current and future loadings of chlorpyrifos and diazinon. These criteria were taken initially from the National Research Council's recommended TMDL model selection criteria (NRC, 2001), and then modified based on local issues and stakeholder concerns. The selection criteria were:

- Links management options to targets
- Appropriate level of complexity
    - Consistent with data
    - Reasonable relative to TMDL development schedule
- Model and results are credible and acceptable
    - Consistent with scientific theory
    - Prediction uncertainty can be quantified
- Acceptable costs
    - Need for long-term support
    - Useful for other TMDLs (e.g., bacteria and metals) & studies

The model selection process identified available models, categorized into four types of models, generally in order of increasing complexity:

- Type 1, large-scale box model
- Type 2, segmented stream model
- Type 3, coupled watershed / waterbody model
- Type 4, biotic response model

The model selection process aggregated two related decisions: 1) selection of the most appropriate model among the four types; and, 2) selection of the most appropriate model that fits each model type. The model selection criteria are summarized in Table 47.

Table 47. Model Selection Criteria and Descriptive Evaluation of Each Model Type for Chlorpyrifos and Diazinon in the CCW

Selection Criteria	Type 1	Type 2	Type 3	Type 4
Links management options to targets	Quantifies total mass per subwatershed; links changes on land to water processes	Need to link changes on land to water processes	Links changes in source loads, water column, and sediment content; no fish tissue model	Only models in-stream processes
Appropriate level of complexity: ▪ Consistent with available data ▪ Reasonable relative to TMDL development schedule	Appropriate for widespread, long time frame problem. Simulations applicable to whole reaches or conglomerate of reaches. Requires the least amount of data. Model development may take days to weeks.	Delineated based on TMDL reaches; can simulate response at a sub-reach scale using short time step. Requires moderate amount of data, which may not be available for CCW. Model development may require weeks to months.	Complex beyond knowledge and scale of sources and processes in CCW; rates require many detected data for calibration and validation; model sensitivity cannot be evaluated adequately with so much ND data. Model development may require months to years.	No data on food webs. Food web complexity and watershed resolution drive model development requirements.
Model and results are credible and acceptable: ▪ Consistent with scientific theory ▪ Prediction uncertainty can be quantified	Similar model used in Bay Area OPs TMDL approved by EPA; uses published rate constants and estimated source/sink loads; could test range of possible reaction rates and loads; can compare to data *trends* but not data *points*	Used in CCW Nutrients TMDL approved by EPA; uses published rate constants and estimated source/sink loads; would compare to data *trends* but not data *points*	Supported by EPA; worldwide applications to hydrology; little published on applicability to simulating OPs; simulates erosion & sediment transport, degradation processes; simulation results can be compared to concurrent observations	Supported by EPA; few applications to streams (lakes more common); insufficient fish tissue data to compare with model results
Acceptable costs: ▪ Need for long-term model support ▪ Useful for other TMDLs and studies	Lowest cost, minimal need for updates; easily converted for any constituent	Already developed and applied in CCW; can be adapted to simulate most constituents	VCWPD may support for flood control and stormwater purposes; could guide future monitoring to fit model input requirements; simulates most constituents	Food web changes over time would need to be monitored; different biota issues for other TMDL constituents

6.1.1 Selected Modeling Approach

The National Research Council (2001) provides some guidance for determining the appropriate level of complexity: "There is a common belief that the expected realism in the model can compensate for a lack of data, and the complexity of the model gives the impression of credibility. Starting with simple analyses and iteratively expanding data collection and modeling as the need arises is the best approach." The selected numerical modeling approach is summarized as follows:

- Set up Type 1 models for the six major subwatershed watershed features: Arroyo Simi, Arroyo Las Posas, Conejo and Calleguas Reaches, Revolon Slough Drainage, and Mugu Lagoon.
- Simulate using a day time step.
- Use the Dynamic Calleguas Creek Modeling System (DCCMS) to generate runoff and in-stream flowrates.
- Develop input loads and concentrations for major sources from available runoff quality data.
- Assume equilibrium conditions for partitioning between dissolved and adsorbed fractions.
- Simulate water column concentrations in creeks as compartments of the box models.
- Validate model performance to the extent possible with in-stream monitoring data.

As the selected model is a Type 1 mass balance approach, a spreadsheet program is used to create the model.

6.2 *Model Description*

The framework for the CCW Toxicity TMDL modeling effort is a spreadsheet-based mass balance water quality model. The model, dubbed the Toxicity TMDL Mass Balance Model (TTMBM), utilizes the flowrate calculations and precipitation data processing of the Dynamic Calleguas Creek Modeling System (DCCMS) developed in support of the Calleguas Creek Salts TMDL Work Plan (LWA, 2004b). A detailed description of the TTMBM is provided in Attachment A.

To model the desired constituents in the CCW, the entire watershed is divided into six subwatersheds based on the major drainages within the watershed, specifically: Arroyo Simi, Arroyo Las Posas, Conejo and Calleguas Reaches, Revolon Slough Drainage, and Mugu Lagoon. The subwatersheds are displayed in Figure 27.

Table 48 provides general information on the TTMBM subwatersheds. Each subwatershed is considered a single complete-mix computational element for determining in-stream flow and calculating the water quality due to processes present along stream reaches circumscribed by the subwatersheds.

Table 48. Toxicity TMDL Mass Balance Model Subwatershed Description

Subwatershed	TMDL Reaches	POTWs	Area		Perimeter
			acres	sq. mi.	mi.
Arroyo Simi	7, 8	Simi Valley WQCP Moorpark WRP	82,951	129.6	66.5
Las Posas	Upper 6	–	21,570	33.7	31.2
Conejo Creek	9B, 10, 11, 12, 13	Hill Canyon WWTP Olsen Rd. (1)	46,812	73.1	49.5
Calleguas Creek	2, 3, Lower 6, 9A	Camarillo WRP Camrosa WRP	17,239	26.9	35.5
Revolon Slough	4, 5	–	39,466	61.7	47.3
Mugu Lagoon	1	–	11,924	18.6	32

1 Olsen Rd decommissioned in 2002, all flow currently diverted to Hill Canyon.

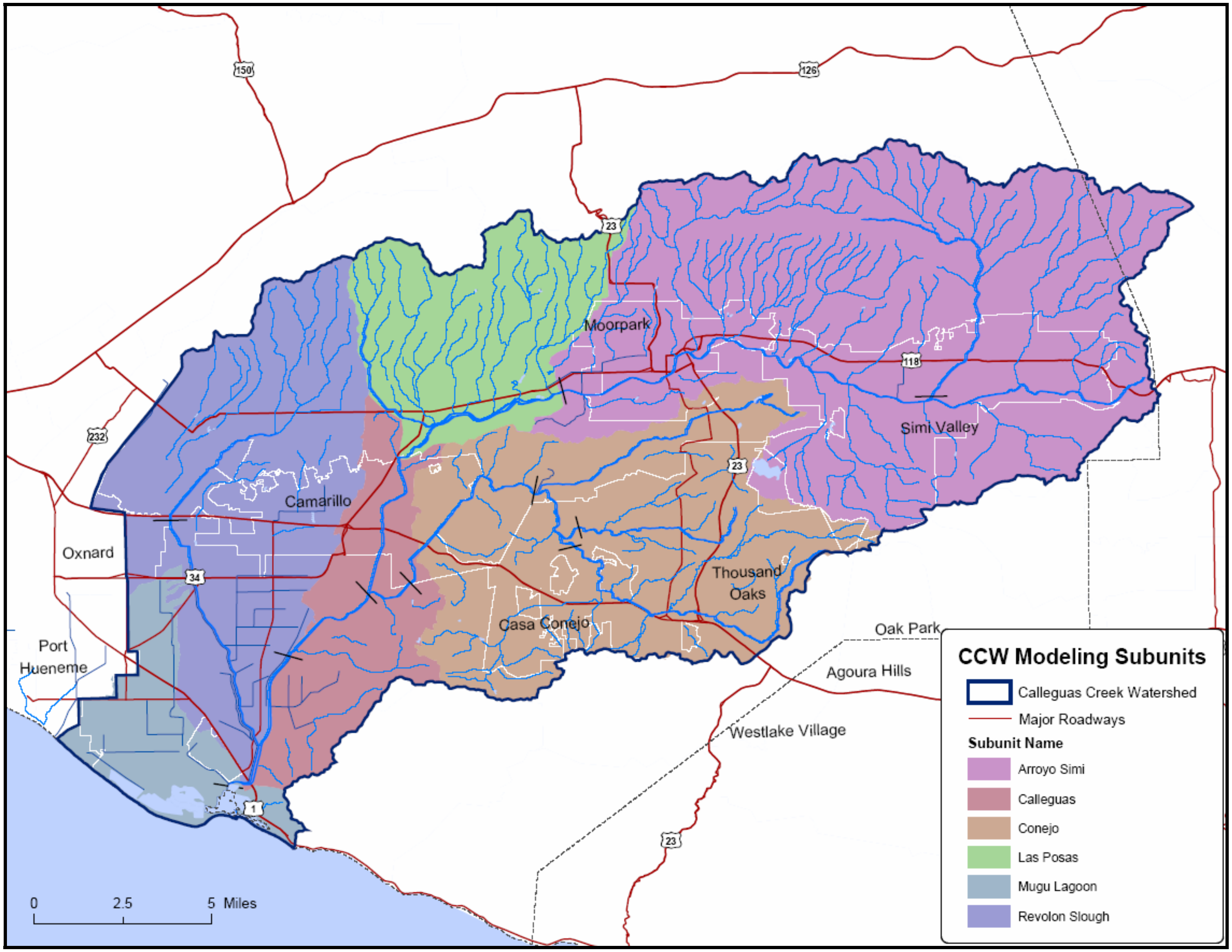


Figure 27. Subwatershed definition sketch for the Toxicity TMDL modeling effort.

Land-use patterns for each of the TTMBM subwatersheds are presented in listed in Table 49. In the Table, the areas of native (undeveloped), agricultural, and urban land uses are listed in terms of percentages of the subwatersheds, percentages of the total land use in the entire CCW, and the actual areas in acres and square miles for each subwatersheds. The calculations are based on the Department of Water Resources 2000 land use GIS data. Based on the information in Table 49, the Arroyo Simi Subwatershed encompasses a total of 82,951 acres (129.6 sq. mi.), and is 72.6% covered with undeveloped native land which is 55.8% of the total native land in the entire CCW.

Table 49. Land Use in Each TTMBM Subwatershed

Subwatershed	Land Use	Percent of Sub-watershed	Percent of Land Use in CCW	Area [1]	
				Acres	Sq. mi.
Arroyo Simi	Native	72.6	55.8	60,243	94.1
	Agriculture	3.6	5.2	2,958	4.6
	Urban	23.8	35.8	19,749	30.9
	Total	100.0	37.7	82,951	129.6
Las Posas	Native	41.8	8.4	9,018	14.1
	Agriculture	54.5	20.6	11,751	18.4
	Urban	3.7	1.5	800	1.3
	Total	100.0	9.8	21,570	33.7
Conejo Creek	Native	47.3	20.5	22,165	34.6
	Agriculture	7.8	6.4	3,657	5.7
	Urban	44.8	38.1	20,990	32.8
	Total	100.0	21.3	46,812	73.1
Calleguas Creek	Native	42.4	6.8	7,315	11.4
	Agriculture	40.2	12.2	6,926	10.8
	Urban	17.4	5.4	2,998	4.7
	Total	100.0	7.8	17,239	26.9
Revolon Slough	Native	12.6	4.6	4,965	7.8
	Agriculture	66.5	46.1	26,260	41.0
	Urban	20.9	14.9	8,240	12.9
	Total	100.0	17.9	39,466	61.7
Mugu Lagoon	Native	35.1	3.9	4,187	6.5
	Agriculture	45.1	9.4	5,374	8.4
	Urban	19.8	4.3	2,363	3.7
	Total	100.0	5.4	11,924	18.6
Whole CCW	Native	49.1	100.0	107,894	168.6
	Agriculture	25.9	100.0	56,926	88.9
	Urban	25.1	100.0	55,141	86.2
	Total	100.0	100.0	219,961	343.7

1 As per Department of Water Resources, 2000

6.3 *Data Used in Model*

Limited data set size and scatter has a great influence on the model development and validation. A summary of data available in the CCW by TTMBM Subwatershed is presented in Table 50. The number of chlorpyrifos and diazinon samples collected by runoff or receiving water type and the percent detected are listed in the table. Detection levels for the majority of chlorpyrifos samples are too high to be environmentally relevant (i.e. the detection limit is higher than applicable water quality criteria). Environmentally relevant detection levels for diazinon are utilized on a far greater percentage of samples than chlorpyrifos.

Data summaries for receiving water data that could be used for validation are listed in Table 51. To further limit the usefulness of the data, several subwatersheds only have detected data corresponding to dry-weather sampling, meaning the wet-weather performance of the model is unverifiable for several subwatersheds. A minimum of three unique detected data and more than 20% of all data must be detected to perform statistical analysis on the data set as per the ROS method, discussed previously in this document (Helsel, 1990). Most of the runoff and receiving water data sets available contain less than 40% detected values. Statistics generated from data sets with less than 40% detected values are considered estimates and are subject to error. Please see the Environmental Data Used section of the Current Conditions and Source Analysis sections for a more detailed discussion of the data used in this TMDL.

Because of limited available data, grab and composite samples are treated in the analysis as equivalent and equally representative of the sampled water, also estimated and qualified data are used as normal detected values. Both uses of the data may introduce errors into the analysis, as grab samples may not be equivalent to composite samples and may not be representative of the targeted source type, and estimated values, while being a better estimate of the true value than the reporting limit, may not reflect the true value in the water accurately. In the TTMBM, it is assumed the receiving water data are representative of surface waters in the entire subwatershed. A related simplifying assumption is that it is assumed the agricultural runoff and urban characterization sites are representative of all like land uses everywhere across the CCW.

Sampling conducted through the TMDL Work Plan Monitoring Plans (LWA, 2004a) helped increase the robustness of the data set used to develop the model. However, many of the above qualifications on the TTMBM can only be removed through continuing monitoring efforts using environmentally relevant detection limits (i.e. the detection limit is higher than applicable water quality criteria).

Table 50. Chlorpyrifos and Diazinon Data Summaries by Source Type in CCW

Source	Chlorpyrifos		Diazinon	
	n	% Detected	n	% Detected
Agricultural Runoff	75	37.3%	66	22.7%
Urban Runoff (1)	47	10.6%	50	54.0%
Pumped Groundwater	4	0.0%	4	0.0%
Effluent Discharge	18	5.6%	19	36.8%
Receiving Water	213	25.8%	239	45.2%

1 Some samples from out-of-watershed characterization site.

Table 51. Available Chlorpyrifos and Diazinon Data for Receiving Waters by Modeling Subwatershed

Subwatershed	Reaches	Chlorpyrifos		Diazinon	
		n	n Detected	n	n Detected
Mugu Lagoon	1	3	1	3	0
Revolon Slough	4, 5	54	33	54	20
Calleguas Creek	2, 3, 9A	52	10	57	32
Conejo Creek	9B, 10 -13	55	3	73	29
Las Posas	6	10	3	10	6
Arroyo Simi	7, 8	39	5	42	21

6.4 *Computational Element*

Each subwatershed is considered one distinct computational element where the inflow and outflow of water and mass are balanced across the subwatershed with conservation equations to calculate changes in in-stream flow and concentration in the receiving water. Over each time step, the stream reach within any subwatershed is assumed to behave as a steady-state complete-mix system. Each day of the simulation is treated as a distinct water quality calculation driven by the flows calculated by the DCCMS. Because of the relatively short reach length, stream geometry, and daily time step; flows can be considered in equilibrium on a daily basis. Assuming that each day is in equilibrium, precludes modeling the routing of peak flows through the CCW; however, the total volume of storm generated flows can be modeled. Assuming that each subwatershed behaves as a complete-mix system implies the in-stream concentration is constant at all locations within a subwatershed (Tchobanoglous and Schroeder, 1985). Because the concentration is modeled as constant for the entire subwatershed, all withdrawals from the reach, including the discharge to the downstream reach will have the same concentration by definition. A schematic of the computational element is displayed in Figure 28 with inputs and outputs displayed with an arrow pointing into the reach for additions, and pointing out from the reach to represent withdrawals. In Figure 28, flows from upstream reaches enter from the right and flow to downstream reaches exit to the left. Scour and deposition, sorption and desorption, sediment content, and direct atmospheric deposition are not currently included in the TTMBM.

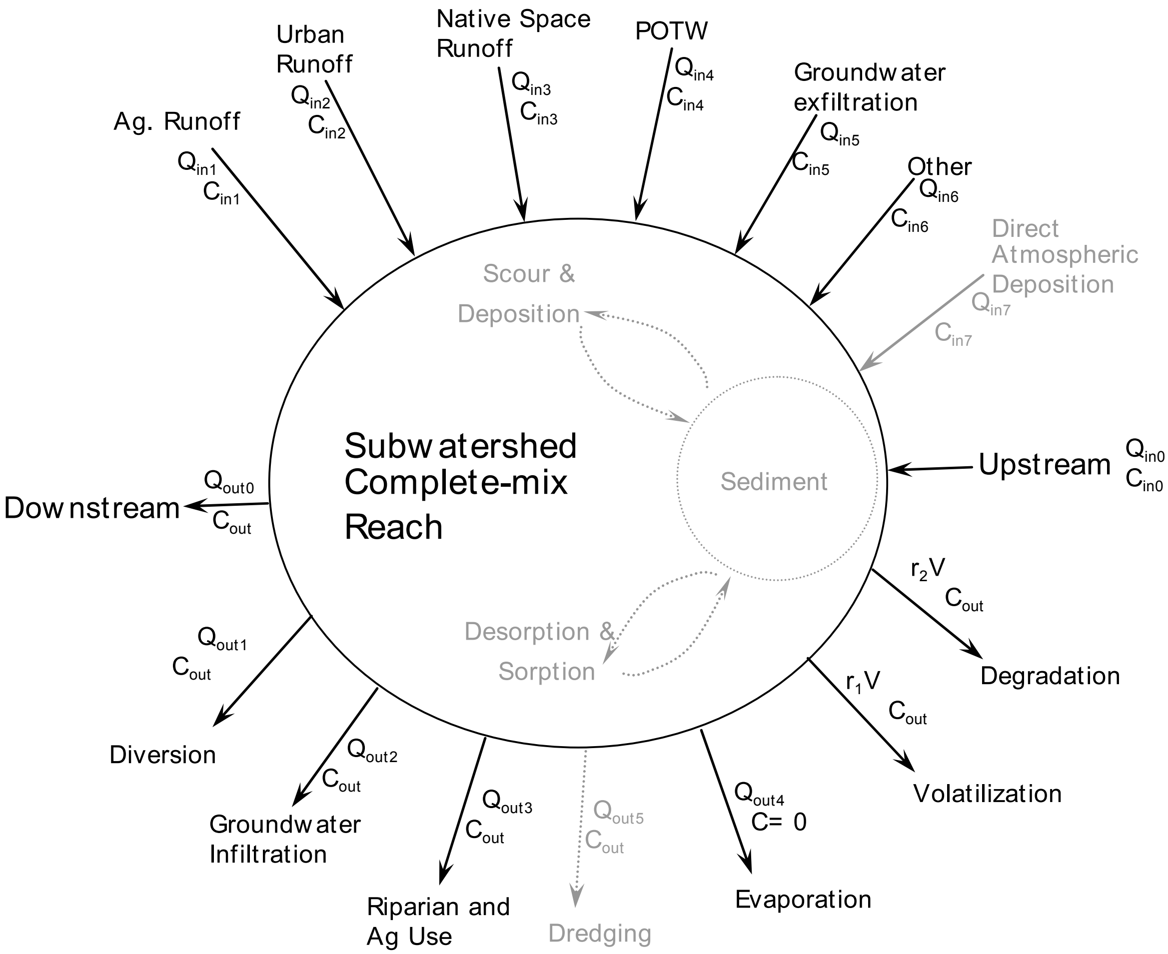


Figure 28. Schematic of inputs and outputs for a general computational element used in the CCMS mass balance model to estimate water flow and quality within surface water reaches. Direct atmospheric deposition, sediment interaction, and dredging are not included in the current version of the TTMBM.

6.4.1 Mass Balance Calculations

To calculate the stream discharge flow and in-stream concentration for a computational element, all inflow rates and concentrations must be specified along with all other withdrawals from the reaches. Each of the daily time steps is assumed to be steady-state. By making the steady-state assumption the ability to model peak flood routing is lost; however because of the relatively small size of the CCW, a smaller time step than one day would be required to capture a flood wave moving through the watershed.

6.4.2 Upstream Subwatersheds

Inflow and mass loading from the upstream subwatershed are added as inputs to the computational element. If the subwatershed is located at the top of a stream's drainage, there will be no upstream subwatershed and the TTMBM will assign a zero value for the flow and mass loading. If multiple upstream subwatersheds contribute to the computational element, the sum of the upstream outflows and sum of the mass loadings are considered.

6.4.3 Subwatershed Inflows of Constituents

Possible inflows considered in the model were: agriculture returns, urban runoff, native runoff, POTWs, groundwater exfiltration, and any other flows.

6.4.3.1 Agriculture Returns to Computational Elements

Agricultural runoff flowrate is calculated via the rational method within the DCCMS. Dry weather runoff is calculated using an average flow per unit area of agriculture land. Wet weather runoff is calculated by multiplying precipitation over the subwatershed by a runoff coefficient and agricultural land fraction of total area. Provisions are included in the DCCMS model to mimic tailing of runoff following precipitation events. For the CCW, only large rain events will cause appreciable, increased in-stream flow for more than one day. In general, the Revolon Slough Subwatershed produces the greatest amount of agricultural runoff, followed by the Las Posas Subwatershed. The Revolon Slough Subwatershed contains the bulk of the agricultural runoff data. Data from all agricultural runoff sites across the entire CCW are aggregated to determine characteristic concentrations of chlorpyrifos and diazinon in the return flows. Assuming that any individual sample is representative of agricultural runoff from any given location in the CCW, the concentration measurements may be paired with the DCCMS calculated agricultural runoff flows to determine loading. Specifically, the calculated agricultural runoff flowrate for the entire Revolon Slough Subwatershed is used to calculate the load from agricultural runoff to Revolon Slough.

In analyses conducted by Stow and Borsuk (2003) and Keller et al. (2004), a power curve was used as a regression for the data. A power relationship describes the change in loading for increasing runoff flowrate, because both changes in concentrations and flows are accounted for in the regression. The results of regressions for chlorpyrifos and diazinon loads in agricultural runoff against runoff flowrate are presented in Figure 29. By definition, the regression equation is the best fit through all the available data. For acute effects, it is more desirable to approximate the peaks in the data.

To provide an estimate of the upper bound to the scatter in the data, the upper 90th percentile prediction level of the regression is used to estimate pesticide loading. Statistically, the 90th percentile prediction interval represents the range where 9 out of 10 (90%) new measurements would fall. The 1 of 10 new measurements plotting outside the prediction interval are equally likely to be above the upper level or below the lower level, so the upper prediction level estimates the maximum of 95% of new measurements. The prediction intervals are calculated for any one additional measurement using standard statistical methods (Neter, et al. 1990). Because the prediction level is determined by an equation based on the regression parameters that would be cumbersome to incorporate into the TTMBM, a power curve is fit to the upper prediction level equation. As can be seen in Figure 29, the power curve fitted to the upper prediction represents the upper bound to the chlorpyrifos and diazinon loads for a large portion of the dataset. Agricultural runoff contribution to in-stream flowrates can exceed 1,000 cfs for the TTMBM subwatersheds. However, the limited range of available water quality data is evident in Figure 29. Figure 29 shows there are only water quality data for samples collected at agricultural runoff sites when the agricultural contributions to in-stream flowrates are less than 200 cfs.

Given the agricultural runoff flowrate in cfs, Equation 2 and Equation 3 are the fitted equations used in the TTMBM (as displayed in Figure 29) to determine the agricultural runoff loads for chlorpyrifos and diazinon in pounds/day, respectively.

Equation 2

$$Load^{chlorpyrifos}_{ag\,runoff} = 0.00231 \cdot Q^{1.310}_{ag\,runoff}$$

$Q_{ag\ runoff}$ = total agricultural runoff flowrate for a subwatershed (cfs)

Equation 3

$$Load^{diazinon}_{ag\,runoff} = 0.00127 \cdot Q^{1.052}_{ag\,runoff}$$

$Q_{ag\ runoff}$ = total agricultural runoff flowrate for a subwatershed (cfs)

In general, chlorpyrifos concentrations appear to increase with increasing daily precipitation, and diazinon concentrations appear to remain relatively constant, however neither regression is well correlated and both are heavily influenced by high concentration light precipitation or low concentration heavy precipitation events.

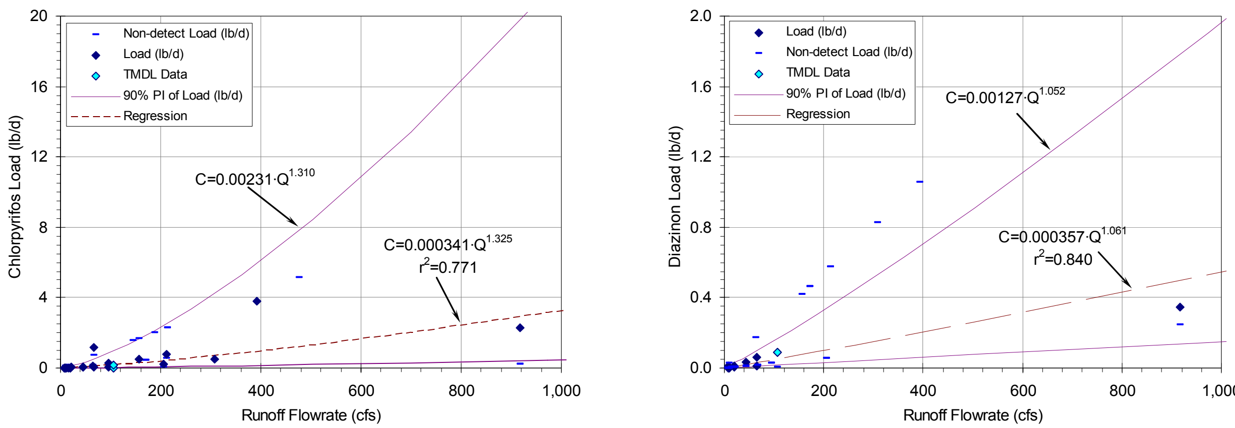


Figure 29. Chlorpyrifos and diazinon load in agricultural runoff as a function of flowrate. Dashed line represents the regression of data and the solid line is a fit to the upper 95th percentile confidence level of the regression. The solid line represents the loading used in the TTMBM.

6.4.3.2 Urban Runoff to Computational Elements

To the extent possible, urban runoff has been analyzed akin to the agricultural runoff. Many of the details discussed above apply to the urban runoff, but have not been repeated in the interest of brevity. Urban runoff is calculated as a mix of runoff from residential, commercial, and industrial land uses. Urban runoff is relatively poorly characterized with data, as indicated by the minimal data presented in the Source Analysis section. The Arroyo Simi and Conejo Subwatersheds produce the greatest amount of urban runoff as they contain a significant amount of urbanized area (Table 49).

As mentioned in the Source Analysis section, chlorpyrifos and diazinon data for urban runoff were collected at selected characterization sites located in Ventura County; however, not all of sites are located in the CCW. It is assumed the characterization sites are representative of all urban sites in the CCW. The chlorpyrifos and diazinon loads as a function of urban runoff flowrate are displayed in Figure 30. In Figure 30, the regression to the data is displayed as a dashed line, and the power curve fit to the 90 percent prediction level of the regression is displayed as a solid line. The 90 percent prediction level is used in the TTMBM to estimate peaks in loadings to the receiving waters.

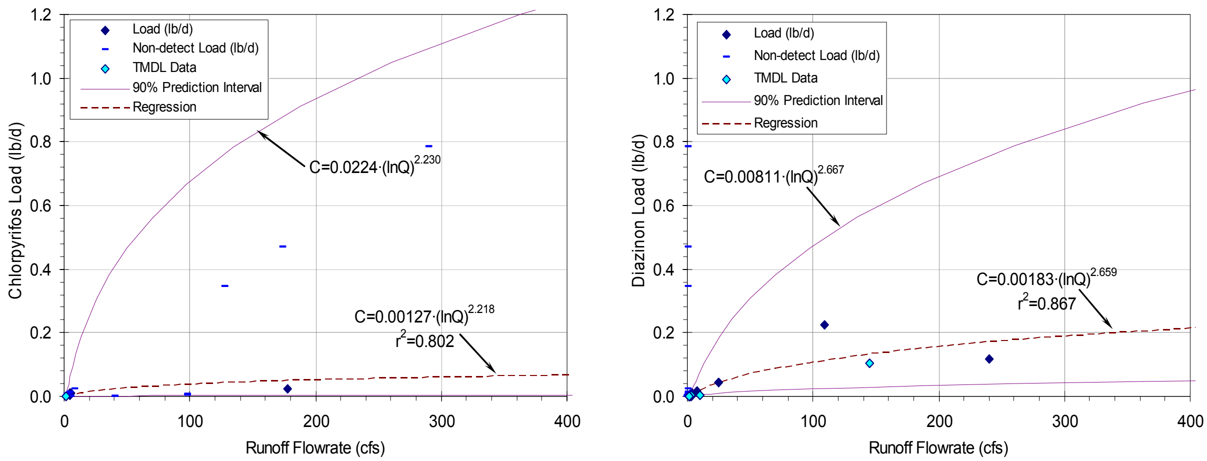


Figure 30. Chlorpyrifos and diazinon load in urban runoff as a function of flowrate. Dashed line represents the regression of data and the solid line is a fit to the upper 90th percentile prediction level of the regression. The solid line represents the loading used in the TTMBM.

While concentrations of chlorpyrifos and diazinon appear to decrease with increasing precipitation, the scatter in the data and limited number of data preclude making a definitive judgment. In-stream diazinon in urban dominated areas is characterized by linear or super-linear (the exponent on the runoff flowrate is greater than 1.0) load as a function of flows leading to the assumption that the urban runoff follows at least a linear relationship. The urban runoff chlorpyrifos and diazinon concentration data are available only for relatively light storms. If data were available for larger storms, a more definitive relationship could be determined. Given the urban runoff flowrate in cfs, Equation 4 and Equation 5, are used in the TTMBM to determine urban runoff loads for chlorpyrifos and diazinon in pounds/day, respectively.

Equation 4

$$Load^{chlorpyrifos}_{urban\ runoff} = 0.0224 \cdot ln\left(Q_{urban\ runoff}\right)^{2.230}$$

$Q_{ag\ runoff}$ = total agricultural runoff flowrate for a subwatershed (cfs)

Equation 5

$$Load^{diazinon}_{urban\ runoff} = 0.00811 \cdot ln\left(Q_{urban\ runoff}\right)^{2.667}$$

$Q_{ag\ runoff}$ = total agricultural runoff flowrate for a subwatershed (cfs)

6.4.3.3 Native (Open Space) Runoff to Computational Elements

The runoff from native areas of vacant, undeveloped, open space is calculated in a manner similar to urban runoff. As no information is currently available describing the native runoff chlorpyrifos or diazinon concentrations or loads in the CCW, the loads for chlorpyrifos and diazinon are calibrated to adjust the TTMBM output to better fit in-stream loads. Because the agriculture, urban, and POTW loads account for essentially all of the in-stream chlorpyrifos and diazinon loads, a detailed calibration of native runoff is unwarranted from a modeling perspective. However, the atmospheric deposition to native open space lands will determine the appropriate implementation action.

6.4.3.4 POTW Inflows to Computational Elements

For the DCCMS, effluent monitoring data from the treatment plants are used to develop statistical descriptions of the effluent flowrate. As described in the Source Analysis section, few data exist characterizing chlorpyrifos and diazinon in POTW effluent. Although use of these pesticides in the urban environment has decreased and in turn, their concentrations in POTW effluent have likely decreased, there is no clear way to adjust the available data to estimate current concentrations. To address the lack of data the effluent concentrations of chlorpyrifos and diazinon for each POTW are set in the TTMBM to the values of 0.05 μg/L, and 0.2 μg/L, respectively. Both values are determined by selecting concentrations in the range of measured values and matching dry weather TTMBM calculated loadings to the measured in-stream values. Multiplying the constant concentration by the DCCMS calculated effluent flowrate is used to determine the loading of chlorpyrifos and diazinon from each POTW to the surface waters in the CCW.

6.4.3.5 Groundwater Inputs to Computational Elements

Groundwater exfiltration and groundwater dewatering discharges are included under the general heading of groundwater inputs. Currently, the only dewatering wells included in the model are located in the Simi Valley Subwatershed. The groundwater flows in the Simi Valley are largely due to continuous pumping to lower the groundwater table. From a modeling perspective, the dewatering well discharges provide baseflow to the stream in an equivalent manner to the natural exfiltration of groundwater. Because available information indicates there is no chlorpyrifos or diazinon load associated with groundwater exfiltration, TTMBM loads are set to zero for groundwater contributions to the stream.

6.4.4 Subwatershed Outflows

Possible withdrawals or outflows from the CCW reaches include groundwater infiltration and diversions, agricultural use, and evaporation. First order degradation (combination of microbial and hydrolysis reactions) and volatilization from the surface waters are included in the TTMBM for both chlorpyrifos and diazinon. However, as the rates are small in comparison to the hydrologic movement through the watershed, the degradation and volatilization do not greatly affect loadings in receiving waters. Because of the complete-mix assumption, the concentration in each of the outflows is equal to the concentration calculated in the reach that is discharged to downstream subwatersheds.

6.4.4.1 Groundwater Infiltration from Computational Elements

Substantial groundwater infiltration occurs in the northern CCW and in the Conejo Creek region and are accounted for in the DCCMS. The infiltration rate is checked internally by the DCCMS to ensure negative flowrates are not produced if the streambed becomes dry. Infiltration removes a load of the constituents from the stream.

6.4.4.2 Riparian Vegetation Demand from Computational Elements

Riparian water demand is estimated in the DCCMS using the evapotranspiration rate and stream-side agricultural and vegetative area. Because the water is drawn from the stream before evaporating, constituents are carried from the stream to the root-zone. Constituents may accumulate in the root zone and would be subject to leaching back into the stream with baseflow; however, the back leaching is not included in the model.

6.4.5 Sediment Interactions

For the purposes of the Toxicity TMDL, sediment may either be suspended in runoff or in receiving waters, or the benthic stream bottom. Diazinon does not preferentially bind to soils and while sediments containing diazinon carried to receiving waters in runoff may be an important transport mechanism, the diazinon will tend to partition into the water phase. Runoff containing sediment and chlorpyrifos are an important transport mechanism to receiving waters. Water column chlorpyrifos (in the dissolved fraction) will interact with suspended and benthic sediments to approach equilibrium, increasing sediment content when water column concentrations are high, and acting to increasing the water column concentration when sediment contents are high. The particular thresholds of low and high are dependent on the sediment composition, organic matter present, etc. The size of colloids overlap the operational definition of suspended sediments and dissolved materials, however for the purposes of the Toxicity TMDL, the sorption of pesticides to colloids is thought to be operationally equivalent to sorption to suspended solids.

An important question that needs to be addressed by this TMDL is whether the numeric targets established are protective of all sensitive ecosystem endpoints. Because sediment quality objectives have not been established by the State of California, there is uncertainty as to what concentrations of chlorpyrifos in sediments are threats to beneficial uses. A review of the literature shows effect levels for benthic invertebrates in the range of 40 – 80 ug/kg. The lowest no-observable effect level found in the literature was 10 ug/kg (Callaghan, 2001). So it is important to ask whether attaining the proposed chronic water quality criteria based numeric target (0.014 ug/L) will ensure that sediments in Calleguas Creek watershed are below 10 ug/kg.

A simple thought experiment demonstrates that the water column targets assure attainment of 10 ug/kg chlorpyrifos in sediments. In the thought experiment (Figure 31), a beaker is filled with 1-liter of highly purified water. The TSS is zero, and the chlorpyrifos concentration is zero. 100 mg of sediments containing 10 ug/kg chlorpyrifos are added to bring the TSS up to 100 mg/L. The resulting chlorpyrifos concentration in the beaker is 0.001 ug/L:

(100 mg sed) x (10^{-6} kg sed / mg sed) x (10 ug chlorpyrifos / kg sed) / 1 L = 0.001 ug/L

Note that it doesn't matter whether or not the chlorpyrifos remains bound to the particles – the total (i.e., unfiltered) chlorpyrifos concentration in the beaker of water will be the same, regardless of adsorption and desorption. Note also that this experiment mimics a process known to occur in the watershed: soils and sediments carrying chlorpyrifos are eroded into surface waters, where they increase the water column total chlorpyrifos concentration.

By the same logic, adding 2000 mg sediment with a chlorpyrifos concentration of 10 ug/kg will bring the concentration in the beaker up to 0.02 ug/kg. This thought experiment can be repeated at different chlorpyrifos levels in sediments, as shown in Figure 32. Given that reaches of the Calleguas Creek watershed often have TSS levels exceeding 1000 mg/L, the conclusion of Figure 32 is that attainment of the 0.014 ug/L water column target is only possible at all relevant TSS concentrations if the concentration of sediments in the Calleguas Creek watershed is less than 10 µg/kg. Therefore, adopting the numeric target of 0.014 ug/L establishes an implicit margin of safety for protection of beneficial uses due to exposure to contaminated sediments.

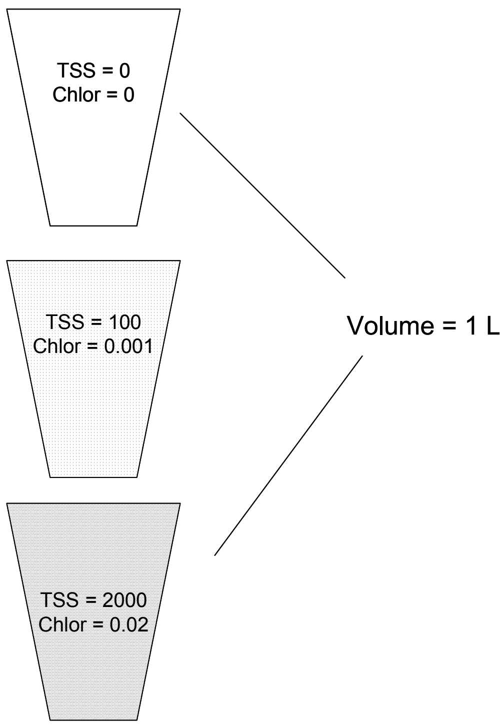


Figure 31. Conceptual illustration of a thought experiment to evaluate how chlorpyrifos in sediments transported to State Waters affects water column concentrations.

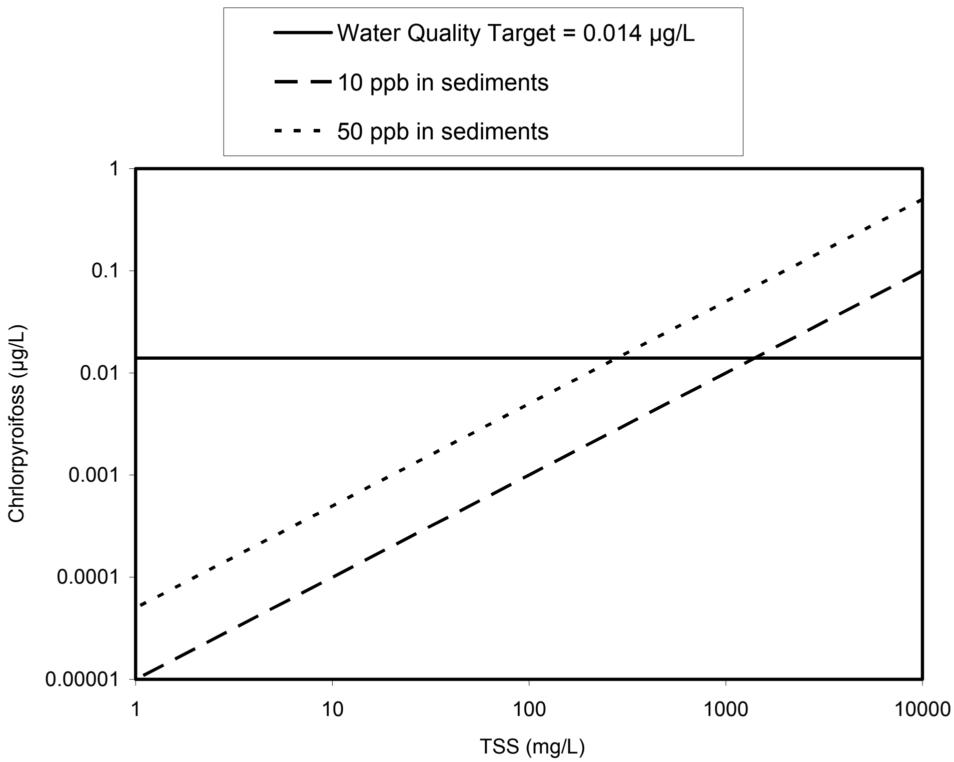


Figure 32. Comparison of how the presence of suspended sediments with 10 µg/kg chlorpyrifos (long dashes) and 50 µg/kg (short dashes) affect water quality compared to the proposed numeric target of 0.014 µg/L (solid line). Note that attainment of the water quality target at all relevant TSS concentrations (up to 2000 mg/L or more) would require sediment with less than 10 µg/kg chlorpyrifos.

Currently, only total concentrations of chlorpyrifos and diazinon are considered in the TTMBM, and there is no distinction between dissolved or particulate fractions. Because the total load of chlorpyrifos and diazinon are calculated by the TTMBM, the sediment associated load to receiving waters is implicitly included in model estimates. The use of total measurements is a conservative utilization of information in that the particle sorbed fraction is likely less toxic than the dissolved fraction. Using the total concentration implicitly assumes that all measured chlorpyrifos and diazinon will equally exert toxicity on aquatic organisms. The transfer between water column and sediment in-stream is not considered in the TTMBM.

6.5 *Degradation and Other Processes*

Degradation of pesticides occurs primarily through the reactions of photolysis and hydrolysis, as well as biodegradation through microbial metabolism. Volatilization is the conversion of a chemical substance from the solid or liquid state to the gaseous or vapor state. This term is often used synonymously with vaporization. Photolysis involves the breakdown of chemicals by the radiant energy of light. Two general modes of photolysis act on pesticides: direct photolysis in which the compound itself absorbs light energy, and indirect or sensitized photolysis by which intermediate compounds, such as hydroxyl radicals, absorb light energy to initiate a breakdown process. Natural conditions that scatter or absorb light affect photolysis rates. Hydrolysis involves a reaction in which a molecular bond is cleaved and a new bond is formed with the hydrogen or hydroxide ion components of a water molecule. Temperature and pH of the water influence this reaction rate. Abiotic or biological oxidation and reduction reactions can also degrade pesticides.

A description of these processes as well as how they are handled in the model is presented below.

6.5.1 Volatilization

Evaporation of water from the reaches is calculated in the DCCMS and used by the TTMBM based on the evaporation rate data multiplied by the estimated water surface area, and is strictly the evaporative loss from the stream surface. Evaporation from the stream surface only removes water from the system thereby increasing the in-stream concentration.

Volatilization of pesticides from soil and water is both a sink (from where it volatilizes) and a source (to the atmosphere, from where it may redeposit) in the watershed. Both diazinon and chlorpyrifos have relatively small Henry's coefficients, and therefore do not tend to volatilize excessively. Dimensionless Henry's coefficients (*H'*) representing the ratio of atmospheric concentration to water concentration range for chlorpyrifos from $1.4 \cdot 10^{-10}$ to $2.7 \cdot 10^{-7}$ (0.0041 to 7.9 $Pa \cdot m^3$/mole) and for diazinon from $2.7 \cdot 10^{-10}$ to $5.6 \cdot 10^{-9}$ (0.011 to 0.14 $Pa \cdot m^3$/mole).

Mackay *et al.* (1997) estimates the half-life volatilization of chlorpyrifos to be nine days for one meter deep streams, which converts to 8.9×10^{-7} m/s. The authors could not find estimates of diazinon volatilization from water. As such, the chlorpyrifos volatilization rate from water is used as the diazinon volatilization rate from water in the TTMBM. This was not expected to have an effect on TTMBM output. Both chlorpyrifos and diazinon have similarly low *H'* values and are considered to be essentially nonvolatile from water. Additionally, the residence time of surface water in the watershed is significantly lower than the volatilization inputs into the TTMBM.

Once volatilized, pesticides may be subject to drift during or following application. Pesticides in drift may enter surface waters directly via atmospheric deposition, or, once deposited in the terrestrial environment, they may be washed off surfaces during rainfall/runoff events. Volatilized chlorpyrifos and diazinon particles can collect in condensed rain droplets that make their way back to surface waters far from the point of application (Hill, 1995). Drift of chlorpyrifos and diazinon is not incorporated into the TTMBM. However, the relatively low vapor pressures of both diazinon and chlorpyrifos are the reason for minimal volatilization from surface waters.

6.5.2 Degradation Processes in Water

Chlorpyrifos is relatively insoluble in water, and hydrolysis and photolysis in the aquatic environment are not considered to be significant degradation processes. Hydrolysis increases significantly under alkaline conditions (USEPA, 1999). Mackay *et al.* (1997) lists the half-life degradation rate in non-sterile water to range from 12 to 27 days. A value in the middle of the range is used in the TTMBM, 16.7 days which equals a first order degradation rate of $4.7x10^{-7}$ 1/s.

Diazinon is moderately soluble in water. Hydrolysis and microbial breakdown are reportedly the principal degradation processes for diazinon in water, with photolysis potentially significant as well (Ogle, 2004). In water, diazinon is stable at pH 7 and pH 9, but hydrolyzes in non-sterile water at a pH of 5 (USEPA, 1988), with a resulting half-life of 12 to 14 days. For neutral or basic conditions, diazinon half-lives are reported to range from 54.6 to 138 days (Giddings, *et al.,* 2000). For river water of pH 7.4, Mackay *et al.* (1997) lists the half-life of diazinon to be 185 days (first order rate of $4.3x10^{-8}$ 1/s) which is the value used in the TTMBM.

6.5.3 Processes in Soil/Sediment

The tendency for a pesticide to adhere to particles or organic matter can be estimated from its octanol-water and organic carbon-water partition coefficients (K_{OW} and K_{OC}); higher coefficients correspond to greater propensity to adsorb. The organic carbon partitioning coefficient (K_{OC}) is the most common value used to evaluate a chemical's adsorption onto particles. K_{OC} measures the "strength" with which a compound sorbs to organic material, including organic coating on sediments, plant and animal detritus, and lipids in organisms. The octanol-water partitioning coefficient (K_{OW}) provides a measure of a compound's tendency to partition into non-aqueous or oily phases rather than dissolve in water.

Diazinon binds only moderately to soil and sediment (K_{OW} 2000 and K_{OC} ~1000-1800), and is moderately soluble in water (mean water solubility of 40 mg/L at 20° C) (Ogle, 2004). Diazinon is subject to relatively rapid degradation by microbial decomposition, with half lives in non-sterile soils of 1-5 weeks. On the soil surface, diazinon may be degraded by photolysis (Ogle, 2004). Diazinon degrades under sterile and anaerobic soil conditions by chemical hydrolysis in acidic soils (Giddings, *et al.,* 2000).

Chlorpyrifos is relatively insoluble in water (mean water solubility of 2 mg/L at 25° C), and adsorbs strongly to organic matter (log K_{OW} 4.70; mean K_{OC} 6070) (USEPA, 1999) indicating that chlorpyrifos is more likely than diazinon to become bound to sediment in the environment. Chlorpyrifos adsorbs fairly strongly to soil organic matter, and readily partitions to sediments in surface waters. Microbial metabolism is the principal degradation process, with hydrolysis potentially significant, particularly in alkaline conditions. Photolysis is not a significant degradation process in soil (USEPA, 1999). In experimental soil and surface applications, chlorpyrifos half-lives ranged from 33 to 56 days and 7 to 10 days, respectively (Fontaine *et al.,* 1987).

Soil degradation process and interactions between aquatic sediments and overlying water are not considered in the TTMBM.

6.5.4 Atmospheric Processes

When released to the atmosphere diazinon is readily degraded via photolysis. Both diazinon and chlorpyrifos may react with hydroxyl radicals in the atmosphere. Neither the mass of chlorpyrifos or diazinon are tracked through the atmosphere in the TTMBM.

6.5.5 Bioaccumulation

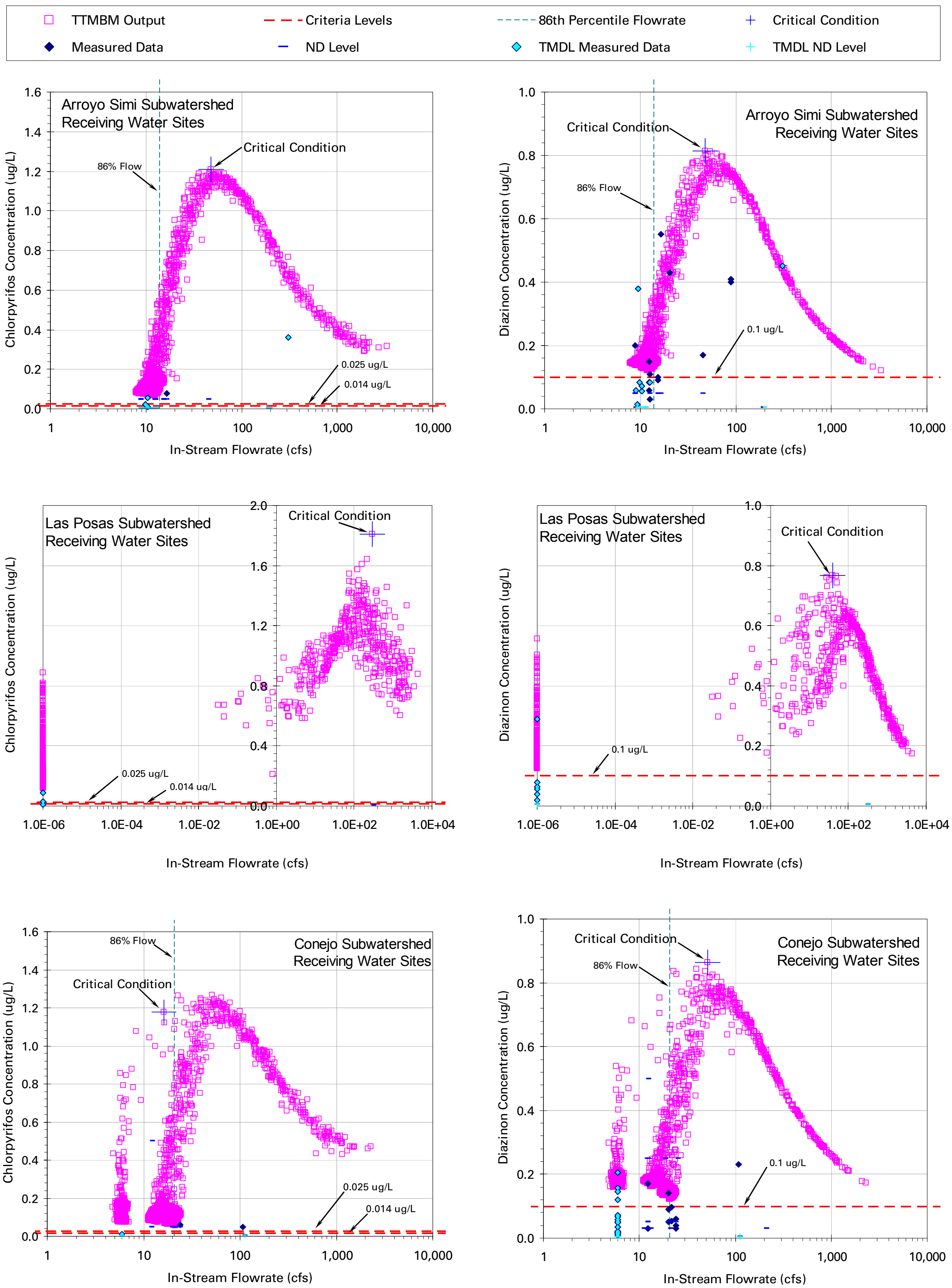
Both chlorpyrifos and diazinon bioaccumulate in freshwater fish, but tissue residues rapidly depurate (within several days of removal from exposure) for both chemicals (Ogle, 2004; USEPA, 1999). As such, it is assumed that reductions in water column concentrations will result in reductions in levels in fish tissue. Bioaccumulation is not explicitly included in the TTMBM.

6.6 *TTMBM Validation*

TTMBM output is compared to all available in-stream measurements of total chlorpyrifos and diazinon for each of the subwatersheds in Figure 33. Because of the conservative approach to model development and the goal of estimating the peak concentrations, the model output (open squares) in-general over predicts the measured data (solid diamonds). Each of the criteria is displayed on the figures, identifying the target levels. The 86th percentile flow for each subwatershed is superimposed on each plot as an estimate of the greatest non-stormwater flowrate. For validation, the TTMBM model output for calculated in-stream loads and concentrations are compared to measured in-stream values. Unfortunately, there are subwatersheds where insufficient in-stream data exist to make judgments of the TTMBM behavior. The following sections discuss TTMBM performance in relation to observed concentrations. Plots comparing available data to model output for each subwatershed are provided in Attachment A.

6.6.1 Arroyo Simi Subwatershed

TTMBM using the 90th percentile prediction intervals overpredicts the measured chlorpyrifos values. Diazinon calculations from the TTMBM match the observed data fairly well. Diazinon concentrations are under-predicted in some instances; however the peak calculated concentration exceeds all measured values. Arroyo Simi receiving water chlorpyrifos or diazinon data for high flow wet weather events is sparse, but the calculated values exceed the available measured values.


TTMBM Output
Criteria Levels
86th Percentile Flowrate
Critical Condition
Measured Data
ND Level
TMDL Measured Data
TMDL ND Level
Arroyo Simi Subwatershed
Receiving Water Sites
Critical Condition
86% Flow
0.025 ug/L
0.014 ug/L
Chlorpyrifos Concentration (ug/L)
In-Stream Flowrate (cfs)
Arroyo Simi Subwatershed
Receiving Water Sites
Critical Condition
86% Flow
0.1 ug/L
Diazinon Concentration (ug/L)
In-Stream Flowrate (cfs)
Las Posas Subwatershed
Receiving Water Sites
Critical Condition
0.025 ug/L
0.014 ug/L
Chlorpyrifos Concentration (ug/L)
In-Stream Flowrate (cfs)
Las Posas Subwatershed
Receiving Water Sites
Critical Condition
0.1 ug/L
Diazinon Concentration (ug/L)
In-Stream Flowrate (cfs)
Conejo Subwatershed
Receiving Water Sites
86% Flow
Critical Condition
0.025 ug/L
0.014 ug/L
Chlorpyrifos Concentration (ug/L)
In-Stream Flowrate (cfs)
Conejo Subwatershed
Receiving Water Sites
Critical Condition
86% Flow
0.1 ug/L
Diazinon Concentration (ug/L)
In-Stream Flowrate (cfs)

Continued

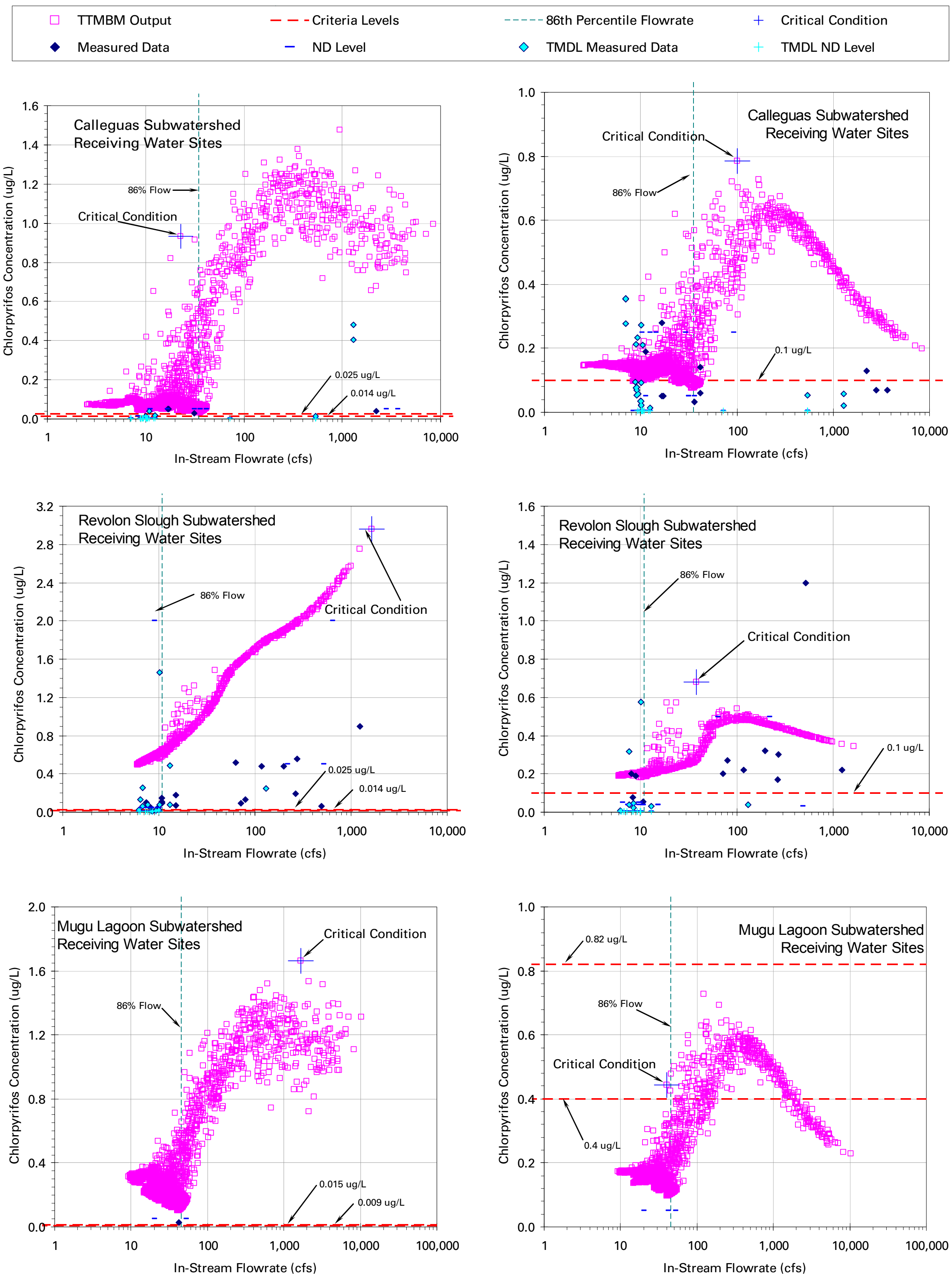


Figure 33. Measured receiving water chlorpyrifos and diazinon concentrations compared to TTMBM output. Note not all figures plotted on the same scale.

6.6.2 Las Posas Subwatershed

The available receiving water data in the Las Posas Subwatershed is more limited than for the Arroyo Simi Subwatershed, only dry weather (i.e. zero subwatershed discharge) chlorpyrifos and diazinon detected value are available for the subwatershed. TTMBM calculated chlorpyrifos and diazinon concentrations match runoff flow patterns and tend to increase substantially during wet-weather. A meaningful comparison of model performance to measured values is not possible due to limited data.

6.6.3 Conejo Subwatershed

The TTMBM over-predicts chlorpyrifos and diazinon loading in dry-weather. There are no available detected measurements for higher flow events. There are too few chlorpyrifos data for a meaningful comparison to TTMBM performance for wet or dry weather conditions. TTMBM matches the trend of available dry weather diazinon data and forms an envelope of peak concentrations.

6.6.4 Calleguas Subwatershed

As with the Conejo Subwatershed TTMBM output over-predicts chlorpyrifos and diazinon dry-weather loads. Wet-weather chlorpyrifos loads are significantly over-predicted. In dry-weather conditions, chlorpyrifos is slightly over predicted and TTMBM output matches trends in observed data. Wet-weather diazinon loads are over-predicted. Diazinon measurements are more scatted than chlorpyrifos during dry-weather, and TTMBM output bounds the measured values in most instances. The dry-weather behavior of most measurements being low with scattered instances of high dry weather concentrations are replicated by the TTMBM. Wet-weather values are over predicted due to the use of the 90th percentile prediction level loading rates. As is the intention, wet-weather concentrations are significantly over predicted by the TTMBM calculations.

6.6.5 Revolon Subwatershed

Chlorpyrifos and diazinon dry-weather loads match the trends of measured loads well, in general over predicting measurements. There are significant scatter in the measured data not reflected in the TTMBM model calculations, however, due to the use of the 90th percentile prediction level loading rates, the TTMBM output typically provides an upper bound to the measurements. A few measurements do exceed the TTMBM calculated values. Wet weather chlorpyrifos concentrations are overpredicted. Trends in diazinon loads are estimated well for wet-weather flows. The TTMBM calculates a nominal concentration of chlorpyrifos and diazinon for a given flow with instances of higher concentrations at flows near the initiation of wet-weather runoff. The data reflect the same behavior of sporadic increase in concentration, but at a lower in-stream flowrate than predicted by the TTMBM. Both chlorpyrifos and diazinon concentrations in general over predicted but match tends of the measured concentrations.

6.6.6 Mugu Lagoon Subwatershed

There are too few chlorpyrifos and diazinon values in the Mugu Lagoon Subwatershed for a meaningful comparison of TTMBM output to measured values. There area no detected diazinon data for the Mugu Lagoon Subwatershed.

6.6.7 Load Apportionment by Subwatershed

In each subwatershed except Revolon Slough, POTW effluent is the major source of both chlorpyrifos and diazinon to the receiving waters for low in-stream flowrates typical of dry weather. As in-stream flowrates increase, agricultural runoff becomes the dominant source of chlorpyrifos and urban runoff becomes the dominant source of diazinon to the receiving waters. In the Revolon Slough Subwatershed, agricultural runoff is the dominant source of both chlorpyrifos and diazinon at all flows according to TTMBM calculations.

6.6.8 Sensitivity Analysis

As discussed in the Source Analysis section, urban and agricultural runoff and POTW effluent provide the bulk of the chlorpyrifos and diazinon loading to the system. Loading of chlorpyrifos and diazinon from urban runoff and POTW effluent are expected to decrease substantially due to the phase-out of urban uses. As such, the TTMBM's sensitivity to urban runoff and POTW effluent is greatly diminished due to the anticipated reductions stemming from the phase-out and is not considered in the sensitivity analysis. The potential atmospheric drift contribution to urban runoff is expected to be dramatically altered due to restrictions on which crops chlorpyrifos and diazinon may be applied to, and re-labeling for application procedures and rates and is not considered in the sensitivity analysis.

As presented in the following section, TMDL and Allocations, the magnitude of required in-stream reductions are between 70 and 99%. Because of the magnitude of reductions, the calculated percent reduction is not sensitive to the exact current or future load in either compartment. To illustrate the insensitivity of the percent reductions required Table 52 lists the change in the required reduction if the actual initial load were 50% greater or less than the TTMBM calculation. For example, if the TTMBM calculated reduction was 99% and subsequently it was determined the current load was 50% less than the calculated load; the actual reduction would need to be 98%. Conversely, if it was determined the current load was 50% greater than the calculated load; the actual reduction would need to be 99.3%.

Due to the magnitude of the reductions, the ultimate answers derived from TTMBM calculations are insensitive to precise current load calculations. As implementation proceeds and loads are reduced in runoff and receiving water there will be an increasing need for model refinement and formal sensitivity analysis to ensure load reductions result in in-stream compliance with numeric targets and allocations.

Table 52. Change in Required Reduction Given a Change in the Calculated Load.

Initial TTMBM Required Reduction (%)	Required Reduction Given Change in Current Load Estimate	
	Current Load 50% Greater	Current Load 50% Less
99	99.3	98
98	98.7	96
95	96.7	90
90	93.3	80
80	86.7	60

6.7 *Conclusions*

Conservation of mass is the basis of the TTMBM water quality model. Flowrates of various reaches in the CCW are calculated by the DCCMS model. By assuming each reach is in steady-state for any given time step, reach outflow and concentration were calculated from algebraic equations. The effect of using a daily time step and the steady-state assumption is to generate a series of daily average snapshots of the conditions likely to exist in the CCW. Both the TTMBM and DCCMS are built on the principles of mass conservation forming a simple, robust, and defensible method of modeling constituent flows through the CCW.

Limitations to the current implementation of the TTMBM include:

- Atmospheric contribution is encapsulated in the agricultural and urban runoff loads of pesticides.
- No measurements of chlorpyrifos and diazinon in the native space runoff in the CCW.
- A linkage between the constituents and TSS and sediments has not been developed.
- A link has not been established between the rate and timing of pesticide use and runoff water quality.

Incorporation of atmospheric drift/direct deposition and wet and dry deposition on the watershed may improve the comparison between TTMBM output and measured in-stream values. Also, estimation of atmospheric deposition loading will allow refined implementation alternatives to address the true source of pesticides to runoff in the CCW. Measurement of chlorpyrifos and diazinon in native space runoff would provide the most direct way of incorporating atmospheric deposition into the TTMBM. Establishing a link between the timing of pesticide application and runoff loading rate may increase the estimation power of the variability in loading by agricultural returns, and if combined with meteorological data may allow estimation of loading by atmospheric deposition.

The current TTMBM utilizes the available information to the extent possible to construct a defensible model constructed under the time constraints of the Toxicity TMDL schedule. In general, the TTMBM output over-estimates chlorpyrifos and diazinon concentrations by design, for estimating potential acute effects. Due to limitations in the available data, there are components of the TTMBM that could be improved. The TTMBM illuminates which sources of the constituents contribute the greatest fraction of in-stream load and under what conditions thus providing decision support for TMDL development. Because of data limitations, the TTMBM output are considered a first-order estimate of actual in-stream conditions. Through continued monitoring and additional investigations, the additional information could greatly improve the predictive capability of the TTMBM.

7 TMDL and Allocations

The loading capacity (LC) for each reach in the CCW, serves as the allowable total maximum daily load of each constituent in the reach. Loading capacity is dependant on in-stream flows and as such is variable. However, by defining a critical condition in the reach, the LC can be calculated by taking the product of the in-stream flow rate at the defined critical condition, the applicable numeric target, and a margin of safety. Equation 6 presents the calculation of the loading capacity.

Equation 6. $\mathbf{TMDL = LC = Q * C_{NT} * MOS *} \boldsymbol{f}$

Where:
LC = Loading Capacity (lbs/day)
Q = In-stream Flow at Critical Condition (cubic feet per second)
C_{NT} = Numeric Target Concentration (ug/L)
MOS = Margin of Safety
f = Conversion factor of 0.00539 [(pounds/day)/(ug/L * cfs)]

The LC is allocated to a waste load allocation (WLA) accounting for all identified point sources, a load allocation (LA) accounting for all identified non-point sources, and a background load (BL) consisting of all loads not identified as described in Equation 7.

Equation 7. **TMDL = LC = WLA + LA + BL**

The loading capacity of a waterbody is allocated to known point and non-point sources, and the background load. Allocations to the sources are established to result in the attainment of numeric targets. WLAs and LAs are allocated for:

- Chlorpyrifos: Allocations are set for chlorpyrifos as it is on the 303(d) list in two of the subwatersheds (Revolon and Arroyo Simi); it has been identified as contributing to toxicity in water in at least two of the subwatersheds (Revolon and Arroyo Simi) and to toxicity in sediment in two subwatersheds (Revolon and Calleguas); and it has been detected above numeric targets in receiving water in all six subwatersheds.
- Diazinon: Allocations are set for diazinon as it is the 303(d) list in one of the subwatersheds (Arroyo Simi); it has been identified as contributing to toxicity in water in two of the subwatersheds (Las Posas and Arroyo Simi); and it has been detected above numeric targets in receiving water in five of the subwatersheds (Revolon, Calleguas, Conejo, Las Posas, and Arroyo Simi).

As noted in the Numeric Targets section, the toxicity target in water is set to equal a toxicity unit (TU_c). The toxicity target in sediment is defined as when a sediment sample exhibits toxicity based on the following two criteria: 1) there is a significant difference ($p<0.05$) in mean organism response (e.g., percent survival) between a sample and the control as determined using a separate-variance t-test, and 2) the mean organism response in the toxicity test (expressed as a percent of the laboratory control) was less than the threshold based on the 90th percentile Minimum Significant Difference (MSD) value expressed as a percent of the control value. These toxicity targets can not be divided into portions and allocated to sources. However, an in-stream loading capacity can be applied and is discussed below.

If additional constituents are identified as contributing to water and/or sediment toxicity and these constituents are not appropriately addressed by other TMDLs, waste load and/or load allocations addressing these constituents will need to be developed.

7.1 *Critical Conditions*

The critical condition is defined in this TMDL as the flowrate at which the TTMBM calculated the greatest in-stream diazinon or chlorpyrifos concentration in comparison to the appropriate criterion. Acute criteria are compared to the calculated daily concentrations from the TTMBM, and chronic criteria are compared to a rolling 4-day arithmetic average of the calculated concentrations. The TTMBM calculates estimates of in-stream concentrations of chlorpyrifos and diazinon for conditions that existed between 10/1/90 and 3/31/04 in the CCW. The flow duration curves for the urban and agricultural runoff flows used by the TTMBM are plotted in Figure 34. By inspection, a “knee” is present in each of the flow duration curves occurring at approximately the 86th percentile flowrate. The “knee” corresponds to precipitation driven runoff representing an estimate of the maximum non-storm flowrate. The 86th percentile flows are identified for reference, but are not used in further analysis. In-stream flowrate duration curves are plotted in Figure 35.

The loading capacity at the critical condition was calculated using Equation 6 with the critical condition flowrate equal to **Q** and chronic numeric targets equal to $\mathbf{C_{NT}}$ for in-stream flowrates less than the 86th percentile flow (non-storm conditions) and acute numeric targets equal to $\mathbf{C_{NT}}$ for flows above the 86th percentile flow (storm flow conditions).

Critical conditions for chlorpyrifos and diazinon in water are presented in Table 53 and Table 54, respectively. These tables present TTMBM calculated in-stream flowrates, percentile flow, season, and applicable numeric target at the critical conditions for each subwatershed. Smaller percentile flows correspond to lower in-stream flowrates, with the 86th percentile flow serving as an estimate of the largest non-storm water flowrate. The 99.86th percentile flow is an estimate of the two year return flow typically considered the “bank full” flowrate in many systems.

There currently is no sediment target for chlorpyrifos; however, as discussed in the Numeric Targets section and demonstrated in the Linkage Analysis section, because of chlorpyrifos’ affinity for particles, this TMDL makes the simplifying assumption that attainment of the water quality criteria based WLAs and LAs for chlorpyrifos will result in attainment of acceptable chlorpyrifos concentrations in suspended and bottom sediments. Through implementation of the TMDL, the replenishment of chlorpyrifos to the sediment will be greatly curtailed, allowing reduction of current contents.

All receiving water measurements and TTMBM calculations are total chlorpyrifos or diazinon measurements, so monitoring and modeling should be capturing critical runoff and water column sediment associated transport of the constituents. The total of dissolved water concentration and particle associated content of chlorpyrifos and diazinon as measured and calculated by the monitoring and TTMBM output ensuring the discharges to Mugu Lagoon will be controlled through the implementation of the TMDL.

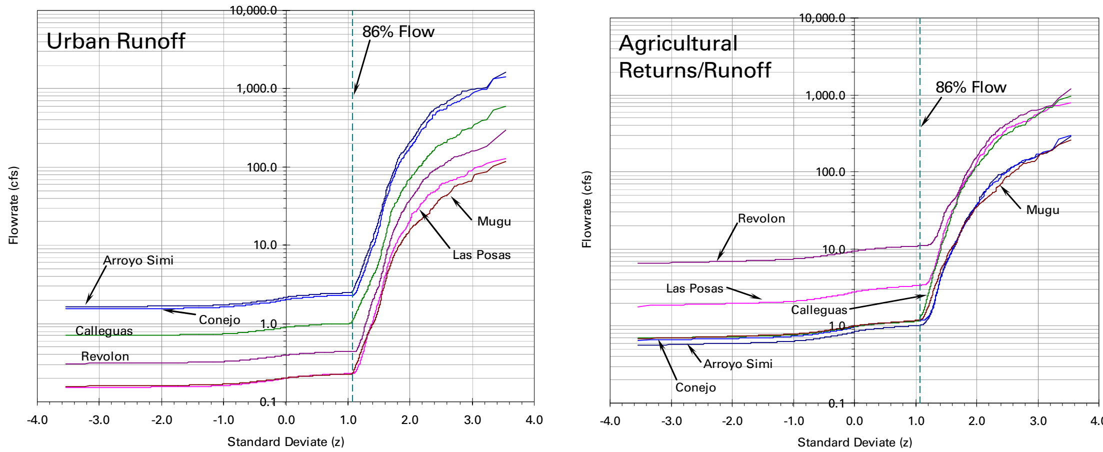


Figure 34. Flow duration curves for urban and agricultural runoff highlighting the 86th percentile flowrate as an estimate of maximum non-stormwater flow.

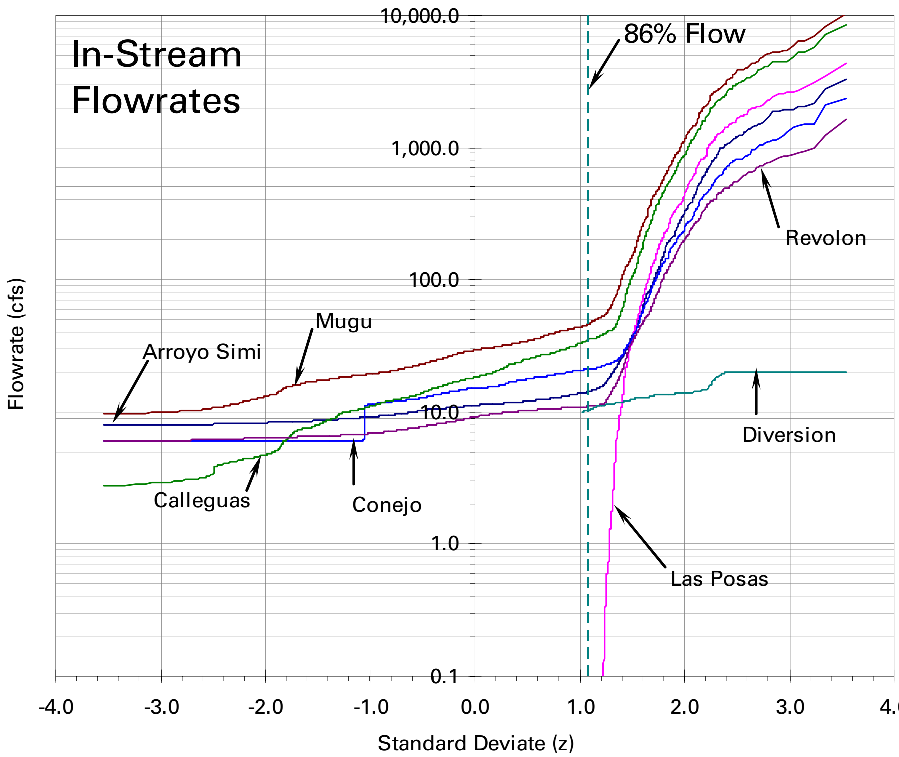


Figure 35. Flow duration curves for in-stream flowrates for each subwatershed in the CCW.

Table 53. Calculated In-Stream Flowrates at Critical Conditions in CCW Subwatersheds for Chlorpyrifos

Subwatershed	Flow (cfs)	Flow Condition	Season	Numeric Target Used
Arroyo Simi	13.7	84th percentile	Dry-Weather	Chronic
Las Posas	0.0[1]	87th percentile	Dry-Weather	Chronic
Conejo	16.4	61th percentile	Dry-Weather	Chronic
Calleguas	29.8	80th percentile	Dry-Weather	Chronic
Revolon Slough	10.5	77th percentile	Dry-Weather	Chronic
Mugu Lagoon	41	79th percentile	Dry-Weather	Chronic

1 Critical condition occurs when stream bed is dry (discharge from subwatershed is 0 cfs), which is the case except during some wet-weather events.
2 Does not include tidal influence as this flow represents freshwater discharge to Mugu Lagoon averaged over entire tidal cycle.

Table 54. Calculated In-Stream Flowrates at Critical Conditions in CCW Subwatersheds for Diazinon

Subwatershed	Flow (cfs)	Flow Condition	Season	Numeric Target Used
Arroyo Simi	40	93th percentile	Wet-Weather	Acute
Las Posas	120	95th percentile	Wet-Weather	Acute
Conejo	44	94th percentile	Wet-Weather	Acute
Calleguas	105	93th percentile	Wet-Weather	Acute
Revolon Slough	38	94th percentile	Wet-Weather	Acute
Mugu Lagoon	37	74th percentile	Dry-Weather	Chronic

1 Does not include tidal influence as this flow represents freshwater discharge to Mugu Lagoon averaged over entire tidal cycle.

7.2 *Comparison of Capacity to Current Loads*

Table 55 presents estimated current chlorpyrifos loads and the loading capacity for each of the six subwatersheds during the critical condition. Table 56 presents the calculated current diazinon load and the loading capacity for each of the six subwatersheds during the critical condition.

Table 55. Comparison of Current Chlorpyrifos Load to Stream Capacity During Critical Condition

Subwatershed	Criteria[1]	Calculated Load (lb/d)	Capacity (lb/d)	Reduction (%)
Arroyo Simi	Acute	0.31	0.0064	97.9%
Las Posas	Acute	2.80	0.0387	98.6%
Conejo	Chronic	0.10	0.0012	98.8%
Calleguas	Chronic	0.11	0.0017	98.5%
Revolon	Acute	26.2	0.221	99.2%
Mugu Lagoon[2]	Acute	15.0	0.226	99.1%

1 Criteria used in evaluation: CDFG for chlorpyrifos of 0.025 μg/L acute and 0.014 μg/L chronic
2 Does not include tidal influence as this flow represents freshwater discharge to Mugu Lagoon averaged over entire tidal cycle.

Table 56. Comparison of Current Diazinon Load to Stream Capacity During Critical Condition

Subwatershed	Criteria[1]	Calculated Load (lb/d)	Capacity (lb/d)	Reduction (%)
Arroyo Simi	Acute	0.21	0.026	88%
Las Posas	Acute	0.17	0.022	87%
Conejo	Acute	0.24	0.028	88%
Calleguas	Acute	0.43	0.055	87%
Revolon	Acute	0.14	0.021	85%
Mugu Lagoon[2]	Chronic	0.097	0.022	16%

1 Criteria used in evaluation: USEPA for diazinon of 0.1 μg/L acute and chronic
2 Does not include tidal influence as this flow represents freshwater discharge to Mugu Lagoon averaged over entire tidal cycle.

7.3 *Waste Load Allocations and Load Allocations*

7.3.1 Alternatives Considered

Five alternatives for allocating waste load and loads for chlorpyrifos and diazinon were considered to meet in-stream numeric targets:

1. Divide the current load reductions required to meet the LC equally between the dischargers.
2. Estimate the reduction of loads from urban and POTW discharges as a result of the urban use bans of chlorpyrifos and diazinon and allocate the remaining reductions to agriculture.
3. Set WLAs and LAs to vary based on in-stream flows.
4. Allocate load reductions to discharges based on an individual discharge's current proportion of the loading during critical conditions.
5. Set WLAs and LAs equal to the numeric target.

Alternative 1 would divide the load reductions required to meet the LC equally between agriculture, urban dischargers, and POTWs. Alternative 1 was rejected as it would require dischargers to reduce their loads without consideration of their current contribution to in-stream impacts. In addition, this could result in requiring individual dischargers to reduce loads beyond their current contributions (i.e. result in reductions greater than 100%).

Alternative 2 would estimate the load reductions that will result from the cessation of sales of chlorpyrifos and diazinon for urban uses. Current loading estimates would be revised to reflect these load reductions and the remaining reductions would be allocated to agriculture. Alternative 2 was rejected as it is unclear what the effect of ceasing sales of chlorpyrifos and diazinon for urban uses will be on urban and POTW loadings. In addition, the time frame for seeing a response to in-stream loadings is unclear. An overestimation or underestimation of the effect on reducing urban and POTW loadings may result in disproportional high or low allocations of load reductions to these dischargers based on their current contributions to in-stream loadings.

Alternative 3 would set variable WLAs and LAs based on in-stream flow. This alternative was rejected as the variable WLAs and LAs would pose a significant technical challenge to match allowable discharge concentrations to in-stream flow. In addition, stakeholders indicated that it would be easier to set WLAs and LAs to be protective in all conditions so that best management practices could be standardized.

Alternative 4 would allocate load reductions and ultimately WLAs and LAs based on each discharger's current proportion of in-stream loading during critical conditions. Alternative 4 was rejected as LAs would be far below target level and WLAs to urban stormwater discharges would be above targets.

Alternative 5 would set WLAs and LAs equal to the numeric targets set forth in the Numeric Targets section. This is a fairly standard practice for establishing WLAs and LAs. Alternative 5 was the selected alternative because it assigns loads equal to numeric targets which require all dischargers to achieve a standard level of protection. Assigning loads in this manner requires individual discharges to address their current contribution to potential in-stream impacts. Alternative 5 will provide a more conservative approach as indicated in the adopted Sacramento County Urban Creeks Diazinon and Chlorpyrifos TMDL (CVRWQCB, 2004).

7.3.2 Development of Allocations

Waste load allocations (WLAs) set equal to water quality criteria based numeric targets are allocated to point source dischargers, including wastewater treatment plants (POTWs) and urban runoff. Load allocations (LAs) set equal to water quality criteria based numeric targets are allocated to nonpoint source dischargers, in this case agricultural discharges. POTWs, urban runoff, and agricultural discharges will be collectively denoted as dischargers. The source analysis and linkage analysis have demonstrated the contributions of chlorpyrifos and diazinon to receiving waters from each of these dischargers are significant.

The sale of diazinon for non-agricultural uses will cease in December 2004. All sales for legal non-agricultural uses of chlorpyrifos will cease in December 2005. However, the use of remaining residential supplies will likely continue for a number of years after the final phase out of these two pesticides. Importation of products from outside of the United States may contain chlorpyrifos or diazinon residue and may lead to continued discharges to the creek system through urban runoff and POTW dischargers. Urban runoff and POTWs will be assigned WLAs to address potential discharges even though urban use within the CCW is assumed to decrease significantly after December 2005.

7.3.3 Allocations

Table 57 presents the chlorpyrifos and diazinon water quality criteria based numeric target WLAs and LAs concentration requirements for the various dischargers to meet in-stream numeric targets. Table 58 presents the loading reductions required of the various dischargers in the six subwatersheds during the critical condition to meet the water quality numeric target based WLAs and LAs. Figure 36 present chlorpyrifos and diazinon loadings from dischargers during wet and dry weather conditions based on reductions of loadings to meet water quality numeric target based WLAs and LAs. Percent reductions presented in Table 58 are after all iterations had been performed, total reductions are in general higher than required reductions reported in Table 55 or Table 56. Note that the reductions are calculated based on the TTMBM calculations of peak watershed loadings. While the reductions listed are necessary for receiving waters to be in compliance with numeric targets over all conditions, there are dischargers and whole subwatersheds that are currently in compliance under some conditions. Table 59 presents calculated receiving water chlorpyrifos and diazinon conditions post implementation and attainment of the water quality criteria based WLAs and LAs for the CCW discharges. The information in Table 58 and Table 59 is presented to demonstrate the effect of dischargers attaining the water quality criteria based WLAs and LAs.

In addition to the final WLAs and LAs, Table 57 also includes phased limits (the terms “phased” and “interim” are often used interchangeably to refer to non-final WLAs and LAs, the term “phased” is used here in accordance with USEPA convention). The sale of diazinon for non-agricultural uses will cease in December 2004. Non-agricultural uses of chlorpyrifos will cease in December 2005. However, the use of remaining residential supplies will likely continue for a number of years after the final phase out of these two pesticides. Continued use may lead to discharges to the creek through urban runoff and POTW dischargers. Phased LAs for chlorpyrifos and diazinon are set in Table 57 to allow reductions in loadings caused by the phase out of uses, educational programs, studies, and the implementation of appropriate BMPs to occur before incorporating final LAs. The phased acute WLAs and LAs are based on the 99^{th} percentile value of discharge data. The phased chronic WLAs and LAs are based on the 95^{th} percentile value of discharge data. The use of the 95^{th} and 99^{th} percentile values to develop phased limits is consistent with current NPDES permitting methodology. All available discharge data presented in the Source Analysis section were used to create a robust data set to calculate the 99^{th} and 95^{th} percentiles. In instances where sufficient data were not available to calculate phased limits, the highest detected value was used. For POTW dischargers all available discharge data from the POTWs in the CCW, presented in the Source Analysis section, were compiled to create a more robust data set. For urban runoff, all available urban runoff data, presented in the Source Analysis section were used to create a more robust data set. Phased limits are based on the available data and may be revised based on additional water quality data, if appropriate.

Table 57. Chlorpyrifos and Diazinon Waste Load and Load Allocations for Dischargers in the CCW

Waste Load Allocations								
POTWs	**Chlorpyrifos (ug/L)**				**Diazinon (ug/L)**			
	Phased[1]		**Final Acute**	**Final Chronic**	**Phased Acute[2]**	**Phased Chronic[3]**	**Final Acute**	**Final Chronic**
Hill Canyon WWTP	0.030		0.025	0.014	0.567	0.312	0.10	0.10
Simi Valley WQCP	0.030		0.025	0.014	0.567	0.312	0.10	0.10
Moorpark WTP	0.030		0.025	0.014	0.567	0.312	0.10	0.10
Camarillo WRP	0.030		0.025	0.014	0.567	0.312	0.10	0.10
Camrosa WRP	0.030		0.025	0.014	0.567	0.312	0.10	0.10
Urban Stormwater Co-Permittees	**Phased[1]**		**Final Acute**	**Final Chronic**	**Phased Acute[2]**	**Phased Chronic[3]**	**Final Acute**	**Final Chronic**
All Subwatershed	0.45		0.025	0.014	1.73	0.556	0.10	0.10
Load Allocations	**Phased Acute[2]**	**Phased Chronic[3]**	**Final Acute**	**Final Chronic**	**Phased Acute[2]**	**Phased Chronic[3]**	**Final Acute**	**Final Chronic**
All Subwatershed	2.57	0.810	0.025	0.014	0.278	0.138	0.10	0.10

1 Phased limit set at the maximum detected value as there were insufficient detected data to develop 99^{th} or 95^{th} percentile.
2 Phased acute limit set at the 99^{th} percentile.
3 Phased chronic limit set at the 95^{th} percentile.

Table 58. Estimated Chlorpyrifos and Diazinon Reductions in the CCW Necessary to Meet Numeric Target Based Waste Load and Load Allocations During Critical Condition[1]

Subwatershed	Total Reduction[2]		Agricultural Runoff[3]		Urban Runoff[3]		POTW[3]	
	Chlorpyrifos	Diazinon	Chlorpyrifos	Diazinon	Chlorpyrifos	Diazinon	Chlorpyrifos	Diazinon
Arroyo Simi	98%	88%	99.4%	68.3%	99.5%	93.0%	72%	50%
Las Posas	99%	87%	99.6%	69.9%	99.5%	93.0%	NA[4]	NA[4]
Conejo	99%	88%	99.4%	68.4%	99.5%	93.0%	72%	50%
Calleguas	99%	87%	99.6%	70.2%	99.5%	93.0%	72%	50%
Revolon	99%	85%	99.0%	70.6%	99.5%	93.0%	NA[4]	NA[4]
Mugu Lagoon[5]	99%	16%	99.0%	68.2%	99.1%	93.0%	NA[4]	NA[4]

1 Criteria used in evaluation: CDFG for chlorpyrifos of 0.025 μg/L acute and 0.014 μg/L chronic; USEPA for diazinon of 0.1 μg/L for both acute and chronic.
2 Reductions based on comparison of maximum calculated in-stream concentrations of chlorpyrifos and diazinon to the CDFG and USEPA criteria, respectively.
3 Reductions proportional to current load contributions.
4 Not applicable because no POTWs discharge to streams in this subunit.
5 Does not include tidal influence as this flow represents freshwater discharge to Mugu Lagoon averaged over entire tidal cycle.

Table 59. Estimated Chlorpyrifos and Diazinon Receiving Water Concentrations During Critical Condition Post Implementation and Achievement of WLAs and LAs

Subwatershed	Critical Criteria		Percent of Target[1]		Receiving Water	
	Chlorpyrifos	Diazinon	Chlorpyrifos	Diazinon	Chlorpyrifos	Diazinon
Arroyo Simi	Chronic	Acute	-25%	-18%	0.0111	0.0845
Las Posas	Chronic	Acute	-47%	-14%	0.0104	0.0873
Conejo	Chronic	Acute	-13%	-5%	0.0132	0.0949
Calleguas	Chronic	Acute	-72%	-18%	0.0089	0.0845
Revolon	Chronic	Acute	-55%	-15%	0.0040	0.0871
Mugu Lagoon	Acute	Chronic	-67%	-29%	0.0090	0.0680

1 The Percent of Target numbers represent the estimated percent difference between the chlorpyrifos and diazinon targets and concentrations in receiving water post implementation and achievement of WLAs and LAs. Note that predicted receiving water concentrations are below numeric targets.

As mentioned previously, the water and sediment toxicity targets can not be converted into a load and divided into portions to be allocated to sources. Additionally, the loading capacity of a stream with regard to a toxicant causing unknown toxicity in water and/or sediment is inherently unknown and can not be allocated. As such, a toxicity allocation equal to the numeric targets will be set at the base of each of the subwatersheds. The toxicity targets will be implemented as a trigger mechanism for initiation of the TRE/TIE process as outlined in USEPA's *Understanding and Accounting for Method Variability in Whole Effluent Toxicity Applications Under the National Pollutant Discharge Elimination System Program* (2000b) and current NPDES permits held by dischargers to the CCW. Setting allocations equal to the numeric targets at the base of each of the subwatershed will result in "loadings" of toxicity in water and sediment at the numeric targets. This provides a mechanism to address all dischargers contributing to in-stream toxicity as individual dischargers may additively cause an in-stream exceedance of the toxicity targets.

There are currently no sediment targets for chlorpyrifos, and therefore no means to calculate required reductions in sediment. As discussed in the Numeric Targets section and demonstrated in the Linkage Analysis section, because of chlorpyrifos' affinity for particles, this TMDL makes the simplifying assumption that attainment of the water quality criteria based WLAs and LAs for chlorpyrifos will result in attainment of acceptable chlorpyrifos concentrations in suspended and bottom sediments. Future monitoring of sediment toxicity, outlined in the Implementation Plan section, will be the measure for evaluating any additional load reductions and/or the development of sediment WLAs and/or LAs for these constituents. It should be noted that the State Board is currently developing sediment quality guidelines. The development of relevant sediment quality guidelines will be incorporated into the CCW Toxicity TMDL WLAs and LAs, if appropriate.

As described in the Current Conditions section, toxicity associated with chlorpyrifos and/or diazinon can be increased due to the presence of each other or other constituents such as ammonia or triazine herbicides. However, the studies that suggest the potential for increased toxicity used concentrations of chlorpyrifos and diazinon at least twice as high as the concentration based WLAs and LAs (Lindstrom and Lydy, 1997; Belden and Lydy, 2000; Bailey *et al.*, in 2001; Anderson and Lydy, 2002). Due to the possibility of additive or potentiated toxicity, achievement of chlorpyrifos and/or diazinon WLAs and LAs may not result in complete removal of toxicity associated with these constituents. However, at this time there is no evidence to suggest conditions in the CCW warrant an adjustment of WLAs and LAs to consider the possibility of additive or synergistic effects. If future monitoring determines WLAs and LAs do not completely remove toxicity associated with these constituents, these allocations may need to be revised.

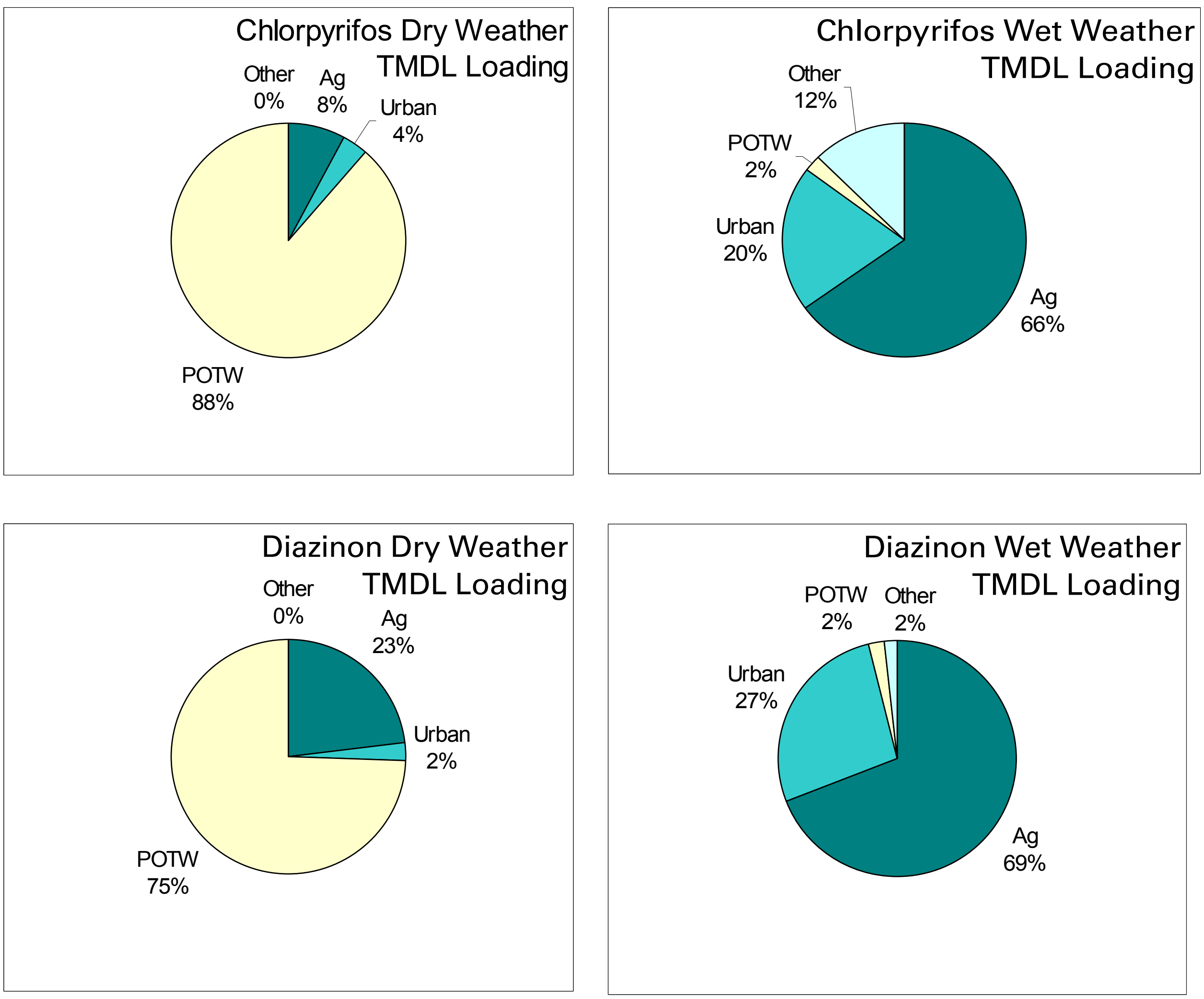


Figure 36. Chlorpyrifos and diazinon loading from various land uses for CCW after complete implementation.

7.3.4 Background Load

Background loading can be allocated to either natural sources and/or sources of loadings directly to a waterbody that are not attributable to a point or nonpoint source. As chlorpyrifos and diazinon are not naturally occurring, a background load would not be applicable under this definition. With regard to loadings that are not attributable to a point or nonpoint source, such as atmospheric and aerial deposition, as discussed in the Source Analysis section the available studies on deposition rates could not be incorporated to determine a specific load of these sources to the CCW. As such, the background load of chlorpyrifos and diazinon is set equal to zero. Potential contributions from background loads are implicitly incorporated into load reductions for identified sources.

7.4 *Margin of Safety (MOS)*

A TMDL analysis involves uncertainty. To address the uncertainty, a TMDL includes a margin of safety, which can be explicit, implicit, or both. The Toxicity TMDL includes an implicit margin of safety by relying on a conservative approach in assignment of water quality criteria based waste load and load allocations. The implicit MOS present in the TMDL is based on this requirement for discharges to meet WLAs and LAs based on water quality numeric targets. This approach follows other chlorpyrifos and diazinon TMDLs developed recently in California such as the USEPA adopted Sacramento County Urban Creeks Diazinon and Chlorpyrifos TMDL (CVRWQCB, 2004) and the Diazinon and Pesticide-Related Toxicity in Bay Area Urban Creeks (SFBRWQCB, 2004). The aforementioned TMDLs do not incorporate an explicit MOS. The following is a list of the conservative actions incorporated into the CCW Toxicity TMDL:

- WLAs for urban stormwater and POTWs are set to the water quality criteria based numeric targets, but use of both constituents is banned in urban areas so the concentrations will likely drop below target levels.
- Implicit in the development of the numeric water quality targets is a margin of safety.
- The WLAs and LAs are set to the water quality criteria based numeric target. Because the contributions to receiving water are dependent on the environmental conditions and behave differently, maximum contribution is a blend of all sources none of which are likely discharging at the target concentration simultaneously.
- Agricultural return flows, urban runoff, and POTWs are the sources of chlorpyrifos and diazinon to the receiving waters in the CCW. Applying the numeric receiving water target to the discharges will ensure the major sources of chlorpyrifos and diazinon to receiving waters are at or below the targets.
- An implicit margin of safety to ensure protection from toxicity due to chlorpyrifos concentrations in sediments exists. As shown in the linkage analysis, attainment of proposed water column target (0.014 ug/L) will ensure attainment of lowest no-effect level of chlorpyrifos in sediments identified in the literature (10 ug/kg).
- The implementation plan describes an adaptive management strategy to incorporate new information, including the State's upcoming sediment quality objectives guidance. When sufficient information exists to establish sediment targets for chlorpyrifos and/or other toxic compounds, those concentrations can be multiplied by the annual sediment flux from the entire watershed and individual sub-watersheds to calculate the assimilative capacity based on sediment concentrations. Thus, it is not expected that sediment quality objectives will produce a more stringent TMDL. Key

information that needs to be developed includes sediment quality objectives for chlorpyrifos and better estimates of sediment transport in the Calleguas Creek Watershed.

7.5 *Seasonal Variation*

Using the TTMBM, a linkage between flows and in-stream water quality was established in each of the subwatersheds. As discussed above, the critical condition was defined as the flowrate at which the TTMBM calculated in-stream diazinon or chlorpyrifos concentration was greatest. The loading capacity at the critical condition was then calculated. The TTMBM was run to ensure the load reductions necessary to meet the loading capacity at the critical condition was protective of all conditions thereby addressing potential issues with seasonal variation.

7.6 *Future Growth*

Ventura County accounts for slightly more than 2% of the state's residents with a population of 753,197 (US Census Bureau, 2000). GIS analysis of the 2000 census data yields a population estimate of 334,000 for the CCW, which equals about 44% of the county population. According to the Southern California Association of Governments (SCAG), growth in Ventura County averaged about 51% per decade from 1900-2000; with growth exceeding 70% in the 1920s, 1950s, and 1960s (Figure 37).

YEAR	POPLN	INCREASE
1900	14,000	--
1910	18,000	28.6%
1920	29,000	61.1%
1930	55,000	89.7%
1940	70,000	27.3%
1950	115,000	64.3%
1960	199,000	73.0%
1970	376,000	88.9%
1980	529,000	40.7%
1990	669,000	26.5%
2000	753,000	12.6%

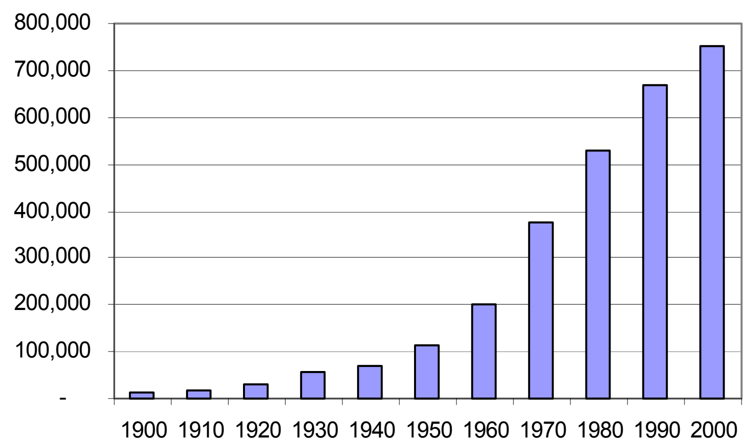


Figure 37. Population growth in Ventura County, 1900-2000 (SCAG, 2004).

Although Moorpark is expected to remain the smallest city as measured by population, it is also expected to have the highest growth rate from 2000-2020 (

Table 60). Both Moorpark and Camarillo are predicted to experience greater than 30% growth in those years. Thousand Oaks is expected to have the lowest growth rate of the CCW cities during that same time period, and is likely to be surpassed by Simi Valley as the most populous city in the watershed by 2020 (SCAG, Minjares, 2004). In general, smaller cities in the watershed are likely to grow faster than larger cities.

Table 60. Growth Projections for CCW Cities and Region, 2000-2020 (SCAG, Minjares, 2004)

City / County / CCW	2000 Popln (July)[1]	2005 Popln (projected)	2010 Popln (projected)	2020 Popln (projected)	% Increase 2000-2010	% Increase 2000-2020
City of Moorpark	31,528	37,611	42,618	43,730	35%	39%
City of Camarillo	57,478	63,179	67,507	76,842	17%	34%
City of Simi Valley	112,190	125,456	131,198	140,902	17%	26%
City of Thousand Oaks	117,418	126,272	129,992	132,925	11%	13%
Ventura County	758,054	821,045	865,149	929,181	14%	23%
CCW[2]	336,121	364,051	383,607	411,999	14%	23%

1 Projected values for June 2000. Actual census values from April 2000 were slightly lower (Ventura County population was 753,197).

2 Values in this row represent a rough estimate, calculated as 44% of the value for Ventura County (based upon the fact that current CCW population is approximately 44% of Ventura County total population).

7.6.1 Growth Management Efforts

Ventura County has been actively involved in growth management for several decades and continues to implement a range of growth management measures such as: urban growth boundaries, ballot-initiative approved zoning, and encouragement of higher density and mixed-use development. The Save Open Space and Agricultural Resources initiative (SOAR) that was passed in 1998 is one such growth management policy. Ventura County's SOAR initiative aims to preserve farmland, open-space and rural areas by establishing a City Urban Restriction Boundary beyond which urban development is controlled (Figure 38). County voter approval is required before any land located outside the City Urban Restriction Boundary can be developed for non-agricultural purposes.

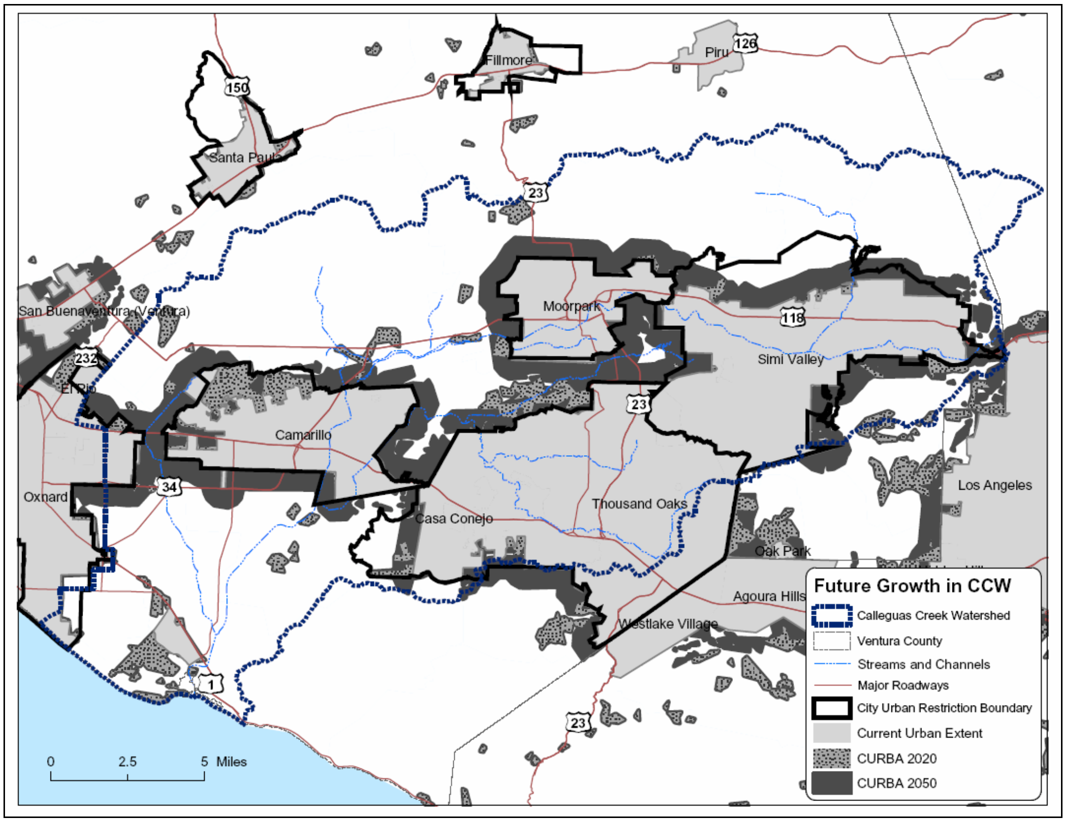


Figure 38. Urban growth in Ventura County (Ventura County CURB, California Urban and Biodiversity Analysis).

The results of California Urban and Biodiversity Analysis (CURBA) for lands within the CCW for the years 2020 and 2050 are also shown in Figure 38 (Landis et al, 1998). CURBA uses an urban growth model to predict future land-use scenarios, and a habitat loss and fragmentation analysis model to estimate the effects of various land use policies upon biodiversity (only results from the urban growth model are considered here). The urban growth model calculates future urbanization probabilities for all undeveloped sites in a given area, according to such factors as: proximity to highways, proximity to city boundaries, site slope, and site development constraints. The CURBA results shown here seem to have been heavily influenced by the “development constraints” variable, as evidenced by the fact that predicted growth is highly correlated with the City Urban Restriction Boundaries established by the SOAR initiative. Since SOAR is due to expire in 2020, it does not provide permanent protection for open space or farmland.

7.6.2 Effects of Growth on Chlorpyrifos and Diazinon Loading

The phase out of chlorpyrifos and diazinon for urban uses will be completed on December 31, 2005. This phase out is expected to reduce loadings from urban and POTWs significantly by 2007. Use of diazinon in agriculture has declined considerably between 1998 and 2003. Conversely, chlorpyrifos use in agriculture has remained relatively stable over the same period. However, as outlined in the Source Analysis section, use modifications for chlorpyrifos have been approved by the USEPA, but not yet approved by DPR. Use modifications for diazinon are currently under negotiations between the manufacturer and the USEPA. Use modifications will change application practices for growers and will likely take effect before the implementation of this TMDL is complete. The phase out of these pesticides in urban environment and the change in use patterns in the agricultural environment will result in a marked decrease in the use of these. Consequently, future growth will not result in increased use or discharge of these pesticides. In addition the WLAs and LAs are set equal to numeric targets which will allow them to appropriately address the potential impact of future growth on the presence of these pesticides in the environment.

The phase out of chlorpyrifos and diazinon as well as population growth will cause an increase in the use of replacement pesticides (e.g. pyrethroids) in the urban environment and may have an impact on water and/or sediment toxicity. Additionally, population growth may affect an increase in the levels of chlorpyrifos and diazinon loading in the CCW from imported products which contain residues of these pesticides. As part of the Implementation Plan the potential for replacement pesticides to cause water and/or sediment toxicity will be investigated through monitoring.

Regardless of the available pesticides, population growth will likely result in greater pesticide loads to POTW influent and urban dischargers. The load will likely increase proportionally to the population increase assuming future domestic water and pesticide load per capita remain stable. Under these assumptions, the volume of wastewater discharged by POTWs would also increase proportionally to population growth. Where impairments do not currently exist, increased flows from POTWs and urban discharges should not result in impairments. However, these assumptions do not take into account two factors 1) market and regulatory forces which dictate the pesticides available to urban users are not predictable over a long time period and 2) the potential of unknown future pesticides to cause water and/or sediment toxicity. As such, a cautious approach should be taken when anticipating the effect of future growth on pesticide loadings and subsequent environmental impact.

Agriculture is currently working through new regulatory processes which will result in changes in pesticide use patterns and likely reduce pesticide loads to the CCW. Conversely, urban users will not necessarily be required to go through similar regulatory processes requiring changes in pesticide use patterns. This suggests that pesticide loads from urban dischargers will increase with future growth. Therefore, the implementation of this TMDL needs to take into account the future use of other pesticides and the potential for this use to contribute to toxicity. To address the potential continued impact from urban uses of pesticides an education program outlining the harmful effects of pesticides, proper use techniques, pesticide alternatives, and integrated pest management will be completed as part of the Implementation Plan. As the potential impact of replacement pesticides is unknown, the unknown toxicity WLAs and LAs set equal to the numeric target will be protective regardless of future growth.

8 Implementation Plan

California Water Code section 13360 precludes the Regional Board from specifying the method of compliance with waste discharge requirements; however California Water Code section 13242 requires that the Basin Plan include an implementation plan to describe the nature of actions to be taken and a time schedule for action. This section describes the proposed implementation plan to meet numeric targets for chlorpyrifos, diazinon and toxicity in the CCW. The Implementation Plan includes the following elements:

- Source control activities to reduce urban sources of pesticides;
- Implementation and evaluation of agricultural best management practices (BMPs) in the watershed;
- Monitoring for diazinon, chlorpyrifos, and toxicity in water and sediment throughout the watershed.

If additional constituents are identified as contributing to water and/or sediment toxicity and these constituents are not appropriately addressed by other TMDLs, an implementation plan to address these constituents will be developed.

8.1 *Waste Load Allocation Implementation*

This section provides a discussion of the application of the final WLAs for MS4s and POTWs, the method for determining compliance with the final WLAs, implementation actions that will be undertaken to achieve the allocations, and the implementation schedule. The final WLAs, listed in Table 57, will be included in NPDES permits in accordance with the compliance schedules provided in the Implementation Schedule section (Table 63), subject to the following condition:

> WLAs may be revised prior to the dates they are placed into permits and/or prior to the dates of final WLA achievement. Any revisions to these WLAs are to be based on the collection of additional information as described in the Special Studies and Monitoring Plan Section.

8.1.1 MS4s

A group concentration-based WLA has been developed for the municipal separate storm sewer system (MS4). USEPA regulation allows allocations for NPDES-regulated stormwater discharges from multiple point sources to be expressed as a single categorical WLA when the data and information are insufficient to assign each source or outfall individual WLAs (40 CFR 130). The grouped allocation will apply to all NPDES-regulated municipal stormwater discharges in the CCW.

MS4 WLAs will be incorporated into the NPDES permit as receiving water limits measured in-stream at the base of each subwatershed and will be achieved through the implementation of BMPs as outlined in this section. Compliance will be determined through the measurement of in-stream water quality and sediment at the base of each of the subwatersheds. To facilitate measuring compliance in all six of the subwatersheds, additional monitoring locations will be needed in four of the subwatersheds (Mugu, Conejo, Las Posas, and Arroyo Simi).

The toxicity numeric targets will be implemented as a trigger mechanism for initiation of the TRE/TIE process as outlined in USEPA's *Understanding and Accounting for Method Variability in Whole Effluent Toxicity Applications Under the National Pollutant Discharge Elimination System Program* (2000b) and current NPDES permits held by dischargers to the CCW.

8.1.2 POTWs

WLAs established for the three major POTWs in this TMDL will be implemented through NPDES permit limits. The proposed permit limits will be applied as end-of-pipe concentration-based effluent limits for POTWs. Compliance will be determined through monitoring of final effluent discharge as defined in the NPDES permit.

The toxicity numeric target will be implemented as a trigger mechanism for initiation of the TRE/TIE process as outlined in USEPA's *Understanding and Accounting for Method Variability in Whole Effluent Toxicity Applications Under the National Pollutant Discharge Elimination System Program* (2000b) and current NPDES permits held by dischargers to the CCW.

The following implementation actions will be taken by Ventura County Stormwater Copermittees and POTWs located in the CCW:

- Plan, develop, and implement an urban pesticides public education program;
- Plan, develop, and implement urban pesticide education and chlorpyrifos and diazinon collection program;
- Study diazinon and chlorpyrifos replacement pesticides for use in the urban environment; and,
- Conduct environmental monitoring as outlined in the Monitoring Plan and NPDES Permits.

As discussed above, additional implementation actions may be necessary, if results of monitoring indicate the phase out of urban uses of chlorpyrifos and diazinon has not adequately addressed related beneficial use impairments.

As discussed in the Numeric Targets and Allocations sections and as demonstrated in the Linkage Analysis section, it is assumed that WLAs for chlorpyrifos will address associated sediment toxicity. However, the State Board is currently developing sediment quality guidelines. The development of relevant sediment quality guidelines will be incorporated into CCW Toxicity TMDL WLAs, if appropriate. The USEPA diazinon criteria may be revised after incorporating comments and additional data submitted by March 30, 2004 as part of the criteria development process. As a result, any revisions to the diazinon water quality criteria will be incorporated into the CCW Toxicity TMDL WLAs, if appropriate.

The sale of diazinon for non-agricultural uses will cease in December 2004. Non-agricultural uses of chlorpyrifos will cease in December 2005. However, the use of remaining residential supplies will likely continue for a number of years after the final phase out of these two pesticides. Continued use may lead to discharges to the creek through urban runoff and POTW dischargers. As the ultimate step to reduce/eliminate the discharge of these pollutants in urban environments, banning use, has already occurred, the phased allocations shown in Table 57 in the allocations section and the implementation schedule presented in the Implementation Schedule section (Table 63) provide sufficient time to allow the pesticide bans and education programs to reduce concentrations in urban runoff and POTW dischargers to or below the WLAs. In addition, it allows time for completion of monitoring to verify the appropriateness of WLAs.

8.2 *Load Allocation Implementation*

LAs for chlorpyrifos and diazinon, presented in Table 57, will be implemented in a manner consistent with the Porter-Cologne Water Quality Control Act. Through Porter-Cologne and the State's Nonpoint Source

Pollution Control Program (NPSPCP), nonpoint source pollution (i.e. Load Allocations) is addressed through the following five key elements of the Policy for the Implementation and Enforcement of the NPSPCP (NPSPCP Implementation Policy):

1. A NPS control implementation program's ultimate purpose must be explicitly stated and at a minimum address NPS pollution control in a manner that achieves and maintains water quality objectives.
2. The NPS pollution control implementation program shall include a description of the management practices (MPs) and other program elements expected to be implemented, along with an evaluation program that ensures proper implementation and verification.
3. The implementation program shall include a time schedule and quantifiable milestones, should the RWQCB so require.
4. The implementation program shall include sufficient feedback mechanisms so that the RWQCB, dischargers, and the public can determine if the implementation program is achieving its stated purpose(s), or whether additional or different MPs or other actions are required.
5. Each RWQCB shall make clear, in advance, the potential consequences for failure to achieve an NPS implementation program's objectives, emphasizing that it is the responsibility of individual dischargers to take all necessary implementation actions to meet water quality requirements.

Under the NPSPCP Implementation Policy, the RWQCBs must regulate all nonpoint sources of pollution, using the administrative permitting authorities provided by the Porter-Cologne Act. One of the permitting authorities available to the LARWQCB is the adoption of a Conditional Waiver from Waste Discharge Requirements. The LARWQCB is currently in the process of developing and adopting a Conditional Waiver for Irrigated Lands (Conditional Waiver Program) to implement the state's NPSMP. Once adopted, the Conditional Waiver Program can be used to ensure implementation of allocations and meeting of numeric targets contained in this TMDL. However, until this program is adopted by the Regional Board, allocations can be implemented directly through a stand alone Basin Plan Amendment that is also consistent with the State's NPSPCP and includes all of the implementation provisions contained herein. In either case, reasonable assurance will be provided that the agricultural controls necessary to meet the LAs will be implemented.

Compliance with LAs will be measured at the monitoring sites approved by the Executive Officer of the Regional Board through the monitoring program developed as part of the Conditional Waiver, or through a monitoring program that is required as part of the Basin Plan Amendment in case the Conditional Waiver Program is not adopted in a timely manner consistent with the TMDL implementation schedule. In either case, monitoring shall be consistent with the Monitoring Plan section of this TMDL. The toxicity numeric target will be implemented in-stream as a trigger mechanism for the initiation of the TRE/TIE process. LAs are based on the available data and may be revised based on additional water quality data, if appropriate.

Studies are currently being conducted to assess the extent of BMP implementation and provide information on the effectiveness of BMPs for agriculture. This information will be used to develop an Agricultural Water Quality Management Plan that will guide the implementation of agricultural BMPs in the CCW. Then, an agricultural education program will be developed to inform growers of the recommended BMPs and the management plan. The Association of Water Agencies of Ventura County and the Ventura County Farm Bureau are actively working on outreach to local growers to educate them on the upcoming requirements from TMDLs and the proposed Conditional Waiver Program.

Replacement of chlorpyrifos and diazinon with other pesticides is not explicitly recommended in this implementation plan as replacement pesticides may pose similar toxicity risks to aquatic life. Rather, the implementation of BMPs should help control the mobilization and discharge of pesticides to receiving waters. Since BMPs have the potential to control discharges of other constituents of interest, such as nutrients and organochlorine pesticides, the implementation of BMPs will be coordinated to achieve the maximum benefit for all constituents of concern. However, if BMPs prove insufficient the only alternative may to replace chlorpyrifos and diazinon.

The phased allocations presented in Table 57 in the Allocations Section and the implementation schedule, shown in Table 63, will provide sufficient time to:

- Allow for the adoption and implementation of the Conditional Waiver Program by agricultural dischargers throughout the CCW;
- Allow for development of an Agricultural Water Quality Management Plan as part of either the Conditional Waiver Program or the Calleguas Creek WMP;
- Allow pesticide bans to reduce concentrations in urban runoff and POTW dischargers;
- Allow label changes for agricultural chlorpyrifos and diazinon products to reduce concentrations in agricultural dischargers;
- Allow for the completion of monitoring to verify the appropriateness of LAs;
- Complete studies to determine the most appropriate BMPs given crop type, pesticide, site specific conditions, as well as the critical condition defined in the development of the LAs;
- Implement appropriate BMPs and monitor to evaluate effect on in-stream water and sediment quality; and,
- Implement adaptive management strategies to employ additional BMPs or revise existing BMPs to met LAs.

As discussed above, implementation of LAs will be conducted over a sufficient period of time to allow for adoption of the Conditional Waiver Program by the Regional Board, as well as coordination with special studies and implementation actions resulting from other TMDL Implementation Plans (Nutrient, Historic Pesticides and PCBs, Metals, Bacteria, Sediment, etc.). As compliance with the chlorpyrifos, diazinon, and toxicity targets are determined in-stream, there is the potential for compliance with the targets without attainment of LAs. As such, LAs may be revised prior to the final LA achievement dates. Any revisions to these LAs are to be based on the collection of additional information as described in the Special Studies and Monitoring Plan sections of the Implementation Plan.

As discussed in the Numeric Targets and Allocations sections and as demonstrated in the Linkage Analysis section, it is assumed that LAs for chlorpyrifos will address associated sediment toxicity. However, the State Board is currently developing sediment quality guidelines. The development of relevant sediment quality guidelines will be incorporated into CCW Toxicity TMDL LAs, if appropriate. The USEPA diazinon criteria may be revised after incorporating comments and additional data submitted by March 30, 2004 as part of the criteria development process. As a result, any revisions to the diazinon water quality criteria will be incorporated into the CCW Toxicity TMDL LAs, if appropriate.

The implementation schedule is designed to parallel, where appropriate, the Nutrient TMDL and Organochlorine Pesticides and PCBs TMDL Implementation Plans. Additional TMDL Implementation Plans may be developed before 2012, for the Metals, Bacteria, and Sediment TMDLs. The implementation schedule for this TMDL may be revised, if appropriate, when the Metals, Bacteria, and Sediment TMDLs are completed.

8.3 *Special Studies*

Several special studies are planned to improve understanding of key aspects related to achievement of WLAs and LAs for the Toxicity TMDL.

8.3.1 Special Study #1 - Monitoring of Sediment Concentrations by Land Use Type

The purpose of this special study will be the identification of sediment concentrations of OP pesticides from representative land uses. The study will be conducted over the course of one year and will include monitoring in urban, agriculture, and native land areas. Once completed, this special study will provide general understanding of overall processes and contributions related to fate and transport of OPs in the CCW. The relevant analytical parameters will be added to the study required for the OCs TMDL.

8.3.2 Special Study #2 - Calculation of Sediment Transport Rates

Under the OCs TMDL, sediment transport rates will be developed for the CCW. The results of this study could be used to evaluate sediment toxicity and sediment loadings for chlorpyrifos in the CCW.

8.3.3 Special Study #3 - Determination of Site Specific Chlorpyrifos and/or Diazinon Criteria

The purpose of this optional special study would be to determine if alternative chlorpyrifos and/or diazinon numeric targets and/or allocations are applicable in various reaches of the CCW given site specific conditions not considered in the original criteria document. The special study could consider averaging periods, resident species, a multi-indicator approach (toxicity assays in conjunction with biological assessments), or the effect of sediment bound chlorpyrifos and diazinon on the toxicity exhibited in water and/or sediment. Possible changes in numeric targets and/or allocations will consider potential affects on sediment toxicity associated with these constituents.

This is an optional special study to be conducted if desired by the stakeholders or determined to be necessary by the Executive Officer.

8.4 *Reevaluation of WLAs and LAs*

A number of provisions in this TMDL could provide information that could result in revisions to the TMDL. Additionally, the development of sediment quality criteria and other water quality criteria revisions may require the reevaluation of this TMDL. For these reasons, the Implementation Plan includes this provision for reevaluating the TMDL to consider state and/or EPA developed sediment toxicity and chemistry criteria, revised methodology for calculating chronic water toxicity, revised water quality objectives/criteria, and the results of implementation studies, if appropriate.

8.5 *Monitoring Plan*

The Monitoring Plan is designed to monitor and evaluate the implementation of this TMDL and refine the understanding of current chlorpyrifos and diazinon loads as well as to continue efforts to identify the cause(s) of remaining or future toxicity in water and sediment. The information presented in this section is intended to be a brief overview of the goals of the Calleguas Creek Watershed TMDL Monitoring Program (CCWTMP) included as Attachment B. The CCWTMP is intended to parallel efforts of the CCW Nutrients TMDL and Organochlorine Pesticides and PCBs TMDL implementation plans.

Monitoring conducted through the forthcoming Conditional Waiver Program may meet part of the needs of the CCWTMP. To the extent monitoring required by the Toxicity TMDL Implementation Plan parallels monitoring required by the Conditional Waiver Program, it shall be coordinated with Conditional Waiver Program monitoring conducted by individuals and groups subject to the terms and conditions of the waiver. The goals of the CCWTMP include:

1. To determine compliance with chlorpyrifos, diazinon, and toxicity numeric targets at receiving water monitoring stations generally located at the base of the subwatersheds and at POTW discharges.
2. To determine compliance with waste load and load allocations for chlorpyrifos, diazinon, and toxicity generally located at the base of the subwatersheds and at POTW discharges.
3. To evaluate presence of sediment toxicity at sediment monitoring stations located in Mugu Lagoon (Reach 1), Lower Calleguas Creek (Reach 2), Calleguas Creek (Reach 3), Revolon Slough (Reach 4), and Conejo Creek (Reach 9A).
4. To identify causes of unknown toxicity and/or potential additive and/or synergistic effects.
5. To generate additional land use runoff data to increase the resolution of current loadings.
6. To monitor the effect of diazinon and chlorpyrifos replacement pesticides on water quality with regard to toxicity.
7. To monitor the effect of implementation actions by urban, POTW, and agricultural dischargers on in-stream water and sediment quality.
8. To implement the CCWTMP in a manner consistent with other TMDL implementation plans and regulatory actions within the CCW.

Current loading estimates are based on limited data. Due to the nature of the data set, assumptions were made about loadings from the various dischargers. The collection of data through the CCWTMP will increase the resolution of current loadings and may indicate the need to refine the WLAs and LAs.

8.5.1 Compliance Monitoring

Monitoring will begin within one year of the effective date of the CCW Toxicity TMDL. In-stream water column samples will be collected quarterly for analysis of water column toxicity, general water quality constituents (GWQC), and targeted organic constituents (including chlorpyrifos and diazinon). In-stream water column samples will generally be collected at the base of each of the subwatersheds (Table 61) until numeric targets are consistently met at these points. At such a time as numeric targets are consistently met at the base of a subwatershed, an additional site or sites within the subwatershed will be considered for monitoring to ensure numeric targets are met throughout the subwatershed.

Additional samples will be collected concurrently at representative agricultural and urban runoff discharge sites as well as at POTWs in each of the subwatersheds and analyzed for GWQC and targeted organic constituents (including chlorpyrifos and diazinon). The location of the land use stations will be determined before initiation of the CCWTMP. TIEs will be initiated on toxic samples as outlined in the Follow-up Toxicity Testing section of the CCWTMP. For organic constituents, environmentally relevant detection limits will be used (i.e. detection limits lower than applicable target), if available at a commercial laboratory. All efforts will be made to include at least two wet weather-sampling events during the wet season (October through April) during a targeted storm event.

Streambed sediment samples will be collected twice a year for analysis of sediment toxicity, general sediment quality constituents (GSQC), and targeted organic constituents (including chlorpyrifos) as presented in Table 61. Sediment samples in Mugu Lagoon will be collected once a year for similar analysis. An annual frequency was selected for Mugu Lagoon sediment sampling due to the relatively slow sedimentation rates in the lagoon in comparison to sample collection depths as discussed in the Sample Collection section of the CCWTMP. TIEs will be initiated on toxic samples as outlined in the Follow-up Toxicity Testing section of the CCWTMP. Fish tissue samples will be collected twice a year in the Revolon Slough subwatershed for analysis of chlorpyrifos. These samples will be used to assess changes in fish tissue concentration as a result of achievement of chlorpyrifos waste load and load allocations.

Table 61. Compliance Sampling Station Locations

Subwatershed	Station ID	Station Location	Sample Media		
			Water	Sediment	Fish Tissue[1]
Mugu Lagoon	01_11_BR	11th Street Bridge	T, OP, OC		OC[2]
	01_BPT_1	Located Near Entrance to Lagoon		T, OP, OC	
	01_BPT_3	Located In The Eastern Arm of the Lagoon		T, OP, OC	
	01_BPT_6	Located In The Eastern Part of the Western Arm		T, OP, OC	
	01_BPT_9	Located Near 17th Street in far side of Western Arm		T, OP, OC	
	01_BPT_15	Located In Central Part of the Lagoon		T, OP, OC	
	01_SG_74	Located In Central Part of the Lagoon In Mudflat Area		T, OP, OC	
Revolon Slough	04_WOOD	Revolon Slough East Side Of Wood Road	T, OP, OC	T, OP, OC	OP, OC
Calleguas	03_CAMAR	Calleguas Creek At University Drive	T, OP, OC	T, OP, OC	OC
	03D_CAMR	Camrosa Water Reclamation Plant	OP, OC		
	9AD_CAMA	Camarillo Water Reclamation Plant	OP, OC		
Conejo	9B_ADOLF	Conejo Creek at Adolfo Road	T, OP, OC	OC	OC
	10D_HILL	Hill Canyon Wastewater Treatment Plant	OP, OC		
Las Posas	06_SOMIS	Arroyo Las Posas off Somis Road	T, OP, OC	OC	OC
	06D_MOOR	Ventura County Wastewater Treatment Plant	OP, OC		
Arroyo Simi	07_HITCH	Arroyo Simi East Of Hitch Boulevard	T, OP, OC	OC	OC
	07D_SIMI	Simi Valley Water Quality Control Plant	OP, OC		

T Toxicity, triazine, and pyrethroid samples will be collected OP Organophosphate samples will be collected
OC Organochlorine Pesticides and PCBs samples will be collected
1 Attempts will be made to collect fish tissue samples in the same location as water and sediment samples. However, samples may be collected elsewhere if no fish are found at pre-established sample stations.
2 Fish tissue sampling locations in Mugu will be determined in conjunction with biologists prior to sample collection.

8.5.2 Toxicity Investigation

Monitoring will begin within one year of the effective date of the CCW Toxicity TMDL. In-stream water column samples will be collected at select sampling stations where the cause(s) of water toxicity have not been identified (Table 62). The sampling schedule for toxicity investigation monitoring occurs during months in which toxicity of unknown causes was observed in previous studies. The CCWTMP will contain provisions to revise the monitoring schedule if it does not adequately characterize toxicity of unknown cause(s). Toxicity investigation samples will be analyzed for water column toxicity, general water quality constituents (GWQC), and targeted organic constituents. TIEs will be initiated on toxic samples as outlined in the Follow-up Toxicity Testing section of the CCWTMP. For organic constituents, environmentally relevant detection limits will be used, if available at a commercial laboratory. As with compliance monitoring, all efforts will be made to include at least two wet weather water sampling events during the wet season (October through April) during a targeted storm event.

Streambed sediment samples will be collected twice a year at select sampling stations where the cause(s) of sediment toxicity have not been identified (Table 62). Streambed sediment will be analyzed for sediment toxicity, general sediment quality constituents (GSQC), and targeted organic constituents. TIEs will be initiated on toxic samples as outlined in the Follow-up Toxicity Testing section of the CCWTMP.

Table 62. Toxicity Investigation Sampling Station Locations

Subwatershed	Station ID	Station Location	Sample Media	
			Water	Sediment
Calleguas	02_PCH	Calleguas Creek Northeast Side of Highway 1 Bridge		X
	9A_HOWAR	Conejo Creek st Howard Road Bridge		X
Conejo	10_GATE	Conejo Creek Hill Canyon below North Fork of Conejo Creek	X	
	13_BELT	Above Confluence with Conejo Creek North Fork	X	

8.5.3 Reporting and Modification of CCWTMP

A Monitoring Report will be prepared annually within three months after the completion of the final event of the sampling year. An adaptive management approach to the CCWTMP will be adopted as it may be necessary to modify aspects of the CCWTMP. Results of sampling carried out through the CCWTMP and other programs within the CCW may be used to modify this plan, as appropriate. These modifications will be summarized in the annual report. Possible modifications could include, but are not limited to the, following:

- The inclusion of additional land use stations to accurately characterize loadings;
- The removal of land use stations if it is determined they are duplicative (*i.e.,* a land use site in one subwatershed accurately characterize the land use in other subwatersheds);
- The inclusion of additional in-stream sampling stations;
- Discontinuation of analysis of sediment fractions;
- The addition of analysis for constituents identified as contributing to toxicity; and,
- The elimination of analysis for constituents no longer identified in land use and/or in-stream samples.

If a coordinated and comprehensive monitoring plan is developed and meets the goals of this monitoring plan that plan should be considered as a replacement for the CCWTMP.

8.6 *Implementation Schedule*

Table 63 presents the overall implementation schedule for the Calleguas Creek Watershed Toxicity TMDL. A concerted effort was made to incorporate ongoing efforts in the CCW with the overall implementation schedule. For instance, two studies assessing agricultural BMPs in Ventura County were initiated in the fall of 2003 and are expected to be completed in 2006.

Since the ultimate step to reduce/eliminate the discharge of diazinon and chlorpyrifos from urban areas, banning use, has already occurred, the implementation schedule presented in Table 63 provides sufficient time to allow implementation measures and the ban to reduce concentrations in the CCW. In addition, time is allotted for the completion of special studies and the reevaluation of the TMDL, if necessary.

Table 63. Overall Implementation Schedule for Calleguas Creek Watershed Toxicity TMDL

	Implementation Action[1]	Responsible Party	Tentative Date
1	Effective date of phased chlorpyrifos and diazinon waste load allocations.[2]	POTWs and MS4 Copermittees	Effective date[1]
2	Effective date of phased chlorpyrifos and diazinon load allocations.[2]	Agricultural Dischargers	Effective date[1]
3	Implement Calleguas Creek Watershed Toxicity Monitoring Program.	POTWs, MS4 Copermittees, and Agricultural Dischargers	Within 1 year of effective date
4	Conduct a study to investigate the pesticides that will replace diazinon and chlorpyrifos in the urban environment, their potential impact on receiving waters, and potential control measures.	POTWs and MS4 Copermittees	Within 2 years of effective date
5	Special Study #1 – Complete monitoring of sediment concentrations by source/land use type through special study required in the OCs TMDL Implementation Plan.	Agricultural Dischargers and MS4 Copermittees	Within 2 years of effective date
6	Develop and implement collection program for diazinon and chlorpyrifos and an educational program. Collection and education could occur through existing programs such as household hazardous waste collection events.	POTWs and MS4 Copermittees	Within 3 years of effective date
7	Development of an Agricultural Water Quality Management Plan in conjunction with the Conditional Waiver for Irrigated Lands, or (if the Conditional Waiver is not adopted in a timely manner) the development of an Agricultural Water Quality Management Plan as part of the Calleguas Creek WMP.	Agricultural Dischargers	Within a 3 years of effective date
8	Identify the most appropriate BMPs given crop type, pesticide, site specific conditions, as well as the critical condition defined in the development of the LAs.	Agricultural Dischargers	Within 2 years of effective date
9	Implement educational program on BMPs identified in the Agricultural Water Quality Management Plan.	Agricultural Dischargers	Within 3 years of effective date
10	Special Study #2 – Consider findings of sediment transport rates in CCW developed through OCs TMDL Implementation Plan.	Agricultural Dischargers and MS4 Copermittees	Within 5 years of effective date
11	Begin implementation of BMPs.	Agricultural Dischargers	Within 3 years of effective date
12	Evaluate effectiveness of BMPs.	Agricultural Dischargers	Within 5 years of effective date
13	Based on the results of Implementation Actions 1 - 12 and if sediment guidelines are promulgated or water quality criteria are revised, and/or if targets are achieved without attainment of WLAs or LAs, reevaluate the TMDLs and WLAs and LAs, if necessary.	Agricultural Dischargers and MS4 Copermittees	Within 2 years of the submittal of information necessary to reevaluate the TMDL
14	Achievement of Final WLAs	POTWs and MS4 Copermittees	2008
15	Achievement of Final LAs	Agricultural Dischargers	2018

1 The Regional Board regulatory programs addressing all discharges in effect at the time this implementation task is due may contain requirements substantially similar to the requirements of this implementation task. If such requirements are in place in another regulatory program, including other TMDLs, the Executive Officer may revise or eliminate this implementation task to coordinate this TMDL implementation plan with other regulatory programs.
2 Phased WLAs and LAs are effective immediately upon TMDL adoption. WLAs will be placed in POTW NPDES permits as effluent limits. WLAs will be placed in stormwater NPDES permits as in-stream limits. LAs will be implemented using applicable regulatory mechanisms.

8.7 *Adaptive Management*

Implementation of the CCW Toxicity TMDL will operate within an adaptive management framework where compliance monitoring, special studies, and stakeholder interaction guide the process as it develops through time. Compliance monitoring will generate information critical for measuring progress toward achievement of WLAs and LAs, and may suggest the need for revision of those allocations in some instances. Additionally, data from ongoing monitoring could reveal necessary adjustments to the implementation timeline and may serve to initiate reevaluation when appropriate. Special studies will increase understanding of specific conditions/processes in the watershed, allowing for more accurate prediction of results expected from various implementation efforts. Thus, adaptive management allows this TMDL to become an ongoing and dynamic process, rather than a static document.

Leadership of the adaptive management program will involve individuals from a range of groups. The LARWQCB will oversee compliance monitoring and any potential need for reevaluation of this TMDL. Various members or stakeholder groups may contribute time and expertise to special studies. The VCWPD has significant resources and personnel dedicated to improving the understanding of sediment transport in watersheds of the region, including the CCW. United Water is involved in a program to monitor effects upon water quality from various agricultural land uses, which will likely generate information beneficial for the efficacy of the Implementation Plan. Many stakeholders have been working together since 1996 toward 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 will 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.

8.8 *Economic Analysis of Implementation*

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. Water Code Section 13141 requires that prior to the implementation of any agricultural water quality control program; an estimate of the total cost of the program and identification of potential sources of financing shall be included in any applicable regional water quality control plan. An analysis of the impacts of implementing these TMDLs with respect to costs, benefits, and other public interests factors is presented below.

The WLA Implementation Plan focuses on education, collection of unused products, water conservation, and monitoring to refine the state of knowledge with regard to current and potential future conditions. A study and a combined education and chlorpyrifos and diazinon collection program will be specifically be completed as part of the WLA Implementation Plan. Table 64 summarizes the goals of the education/collection program and study as well as estimated costs.

Table 64. Waste Load Allocation Implementation Plan Actions and Cost Estimates

Implementation Action and Goals	Estimated Cost
Develop and implement urban educational and collection program. The goals of this program are: 1. Provide information on: • The ban and restrictions on use of chlorpyrifos and diazinon. • The harmful effects of chlorpyrifos and diazinon and the potential effects of replacement products on the environment. • The proper use and disposal of pesticides. • Alternative pest control techniques including integrated pest management. • Methods for reducing urban water use and runoff. • Collect a portion of the remaining chlorpyrifos and diazinon stocks held by domestic users. 2. Assess effectiveness of program.	$150,000/year for a minimum of three years
Study diazinon and chlorpyrifos replacement pesticides for use in the urban environment. The goal of this study is to investigate the pesticides that will replace diazinon and chlorpyrifos in the urban environment, their potential impact on the beneficial uses in receiving waters, and potential control measures.	$30,000

The LA Implementation Plan focuses on education, water conservation, and implementation of BMPs. Table 65 summarizes the goals of the programs and studies as well as estimated costs. Table 65 summarizes the estimated unit costs and watershed wide costs associated with implementing various BMPs. Currently it is unclear which BMPs have been implemented in the CCW or the extent to which those BMPs have been implemented. Because of this, in developing the estimated cost for implementing BMPs it was assumed that 1) no BMPs are implemented in the CCW and 2) all BMPs would be required on all agricultural lands applying diazinon or chlorpyrifos. Cost estimates were developed by selecting the least and most expensive options by category for the low and high cost estimates, respectively. The total acreage considered was determined by averaging the total acres to which chlorpyrifos and diazinon were applied to between 1998 and 2003 based on PUR data. The range of estimates is likely high given the broad assumptions used.

Table 65. Load Allocation Implementation Plan Actions and Cost Estimates

Implementation Action and Goals	Estimated Cost
Develop and implement an Agricultural Water Quality Management Plan. The goal of this action is develop a management plan to address identified water quality impairments and meet water quality objectives.	$700,000
Identify appropriate BMPs and the extent to which BMPs are currently implemented in the CCW. The goal of this action is to complete studies to determine the most appropriate BMPs for the CCW given crop type, pesticide, site specific conditions, as well as the critical conditions as well as the current BMPs utilized in the CCW and the extent to which they are currently implemented.	This work is currently being conducted and will not require additional funding.
Develop and implement agricultural BMP education program. The goals of this program are to: 1. Provide information on: • BMPs identified in the aforementioned studies as well as other BMPs deemed to be effective at reducing runoff to waterbodies given crop type, pesticide, site specific conditions, as well as the critical conditions. • The restrictions on use of chlorpyrifos and diazinon. • The harmful effects of chlorpyrifos and diazinon and the potential effects of replacement products. • The proper use and disposal of pesticides. • Alternative pest control techniques including integrated pest management. • Methods for reducing water use and runoff. 2. Assess effectiveness of program.	$75,000/year for a minimum of three years
Implement BMPs. The goal of this action is to implement BMPs to address diazinon, chlorpyrifos, and toxicity of unknown causes and to assess the effectiveness of BMPs.	$3,300,000 – 140,000,000

Table 66. Estimated Costs for Applicable Agricultural Best Management Practices (BMPs) for Reducing Pesticide Loading[1,2]

Agricultural BMP	Units	Cost Range Per Unit		Cost Range For Watershed (note acreage and how defined)	
		Low	High	Low	High
Conservation Tillage					
No Till	acre	-$11.50	$5.70	-$227,800	$112,900
Mulch Till	acre	$11.50	$22.90	$227,800	$453,600
Contour Farming	acre	$9.20	$114.60	$96,600	$1,203,300
Contour Orchard and Other Fruit Area	acre	$114.60	$149.00	$1,203,300	$1,564,500
Crop Residue Use					
Chopping and Chopping Waste	acre	$28.70	$68.80	$568,500	$1,362,800
Mulching using min. Tillage	acre	$11.50	$28.70	$227,800	$568,500
Filter Strip					
Filter Strip (10-20 ft wide)	acre	$430	$14,326	$80,500	$2,682,500
Filter Strip (20-40 ft wide)	acre	$430	$14,326	$161,000	$5,364,900
Filter Strip (40-60 ft wide)	acre	$430	$14,326	$321,900	$10,729,900
Buffer Strip (20-30 ft wide)	acre	$487	$1,948	$182,400	$729,600
Landscaping (20-30 ft wide)	acre	$516	$4,011	$193,100	$1,502,200
Grassed Waterway	acre	$430	$14,326	$403,400	$13,412,300
Hillside Bench	acre	$40	$2,120	$421,050	$22,262,100
Irrigation Systems					
Irrigation System: Sprinkler	acre	$401	$1,261	$7,945,000	$24,971,950
Irrigation System: Trickle					
Microspray System	acre	$974	$3,667	$19,296,050	$72,643,900
Drip Irrigation	acre	$2,120	$4,126	$41,996,900	$91,723,850
Irrigation System					
Tailwater Recovery	each	$5,157	$28,652	NC	NC
Irrigation Water Management	acre	$57	$28,652	$1,135,000	$17,025,000
Runoff Management system					
Sediment Basin	each	$802	$1,150,000	NC	NC
Infiltration Trench	per foot	$17	$86	NC	NC
Sediment Trap, Box Inlet	each	$212	$974	NC	NC
			Total[3]	**$3,300,000**	**$140,000,000**

NC Not calculated as there was not a clear method for estimating the total units needed.
1 From: Calleguas Creek Watershed Erosion and Sediment Control Plan for Mugu Lagoon (NRCS, 1995).
2 Costs adjusted from 1995 to 2000 using Engineering News Record Construction Cost Index.
3 The total for the Low Cost Range determined by selecting the least expensive BMP from each subgroup. The total for the High Cost Range determined by selecting the most expensive BMP from each subgroup.

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Appendix I. Mugu Lagoon Data Summary Discussion

Introduction

Calleguas Creek Reach 1 (Mugu Lagoon) is currently on the 303(d) list for sediment toxicity. The listing is based on data collected through the California State Water Resources Board's Bay Protection and Toxic Cleanup Program (BPTCP) in 1993. The purpose of this Appendix is to summarize available sediment toxicity and sediment chemistry data for the Lagoon collected since 1993 in an effort to determine the persistence of sediment toxicity, identify potential causes of observed toxicity, and to help guide future monitoring activities to support development of the toxicity TMDL.

Summary of Existing Toxicity Data for Mugu Lagoon

Research was conducted to identify sediment toxicity data collected for Mugu Lagoon since the testing performed by the BPTCP in 1993. A summary of the existing toxicity data evaluated is provided in Table 1 and summarized in detail in this Appendix. As indicated in Table 1, additional tests were conducted by the BPTCP in 1997; the Naval Air Weapons Station (NAWS) conducted testing as part of the Phase I Remedial Investigation (RI); the Naval Base Ventura County (NBVC) performed testing as a validation to testing conducted for the NAWS RI; and Michelle Anghera collected sediment toxicity and chemistry data for a graduate degree while at UCLA. Each of these studies is discussed below. Because of several differences in methodologies among these studies (e.g. sample collection, test methods) the studies are not directly comparable and therefore only a qualitative analysis of these studies could be performed.

BPTCP

In addition to the tests conducted in 1993 that are the basis for the 303(d) listing for Reach 1, the BPTCP performed sediment toxicity tests in April 1994 and February 1997. As indicated in Table 2 several stations monitored in Mugu Lagoon demonstrated significant toxicity when compared to control organisms; these sites are also plotted in Figure 1 according to percent survival.

Sediment samples were also analyzed for PAHs, pesticides, metals, and total PCBs. As discussed in the following section, sediment concentration results were used to evaluate the relationship between sediment chemistry and biological impacts. Sediment samples were collected as grab samples to a desired depth of 10 cm. Once collected, overlying water was removed and the top 2 cm of surficial sediment was sub-sampled from the grab.

Table 1. Toxicity Studies Conducted in Mugu Lagoon

Agency	Study	Dates	Locations	Species Tested (acute unless otherwise noted)	Sediment Chemistry Collected
SWRCB	BPTCP	April 1994; February 1997	Mugu/Entrance; West Mugu Lagoon; Central Mugu Lagoon; East Mugu Lagoon	Amphipod *Eohaustorius* Amphipod *Rhepoxynius*	Yes, analyzed for PAHs, pesticides, metals, and total PCBs.
NAWS Pt. Mugu	Phase I Remedial Investigation	February 1994	Sites 2, 4, and 5	Amphipod *Ampelisca* Amphipod *Eohaustorius* (chronic) Polychaete *Neanthes* (chronic)	No, sediment samples were analyzed as part of the study but were not collected simultaneously with toxicity samples.
NBVC Pt. Mugu	Ecological Risk Assessment	December 1997	Site 11	Amphipod *Ampelisca*	Yes, co-located with toxicity samples and analyzed for PAHs, pesticides, and metals.
UCLA	Graduate study performed by Michelle Anghera	February 2001	Four sites each on two tidal creeks (four adjacent to NBVC reference sites); 6 sites in the lagoon mudflat	Amphipod *Eohaustorius*	Yes, analyzed for metals, pesticides, PCBs, and PAHs.

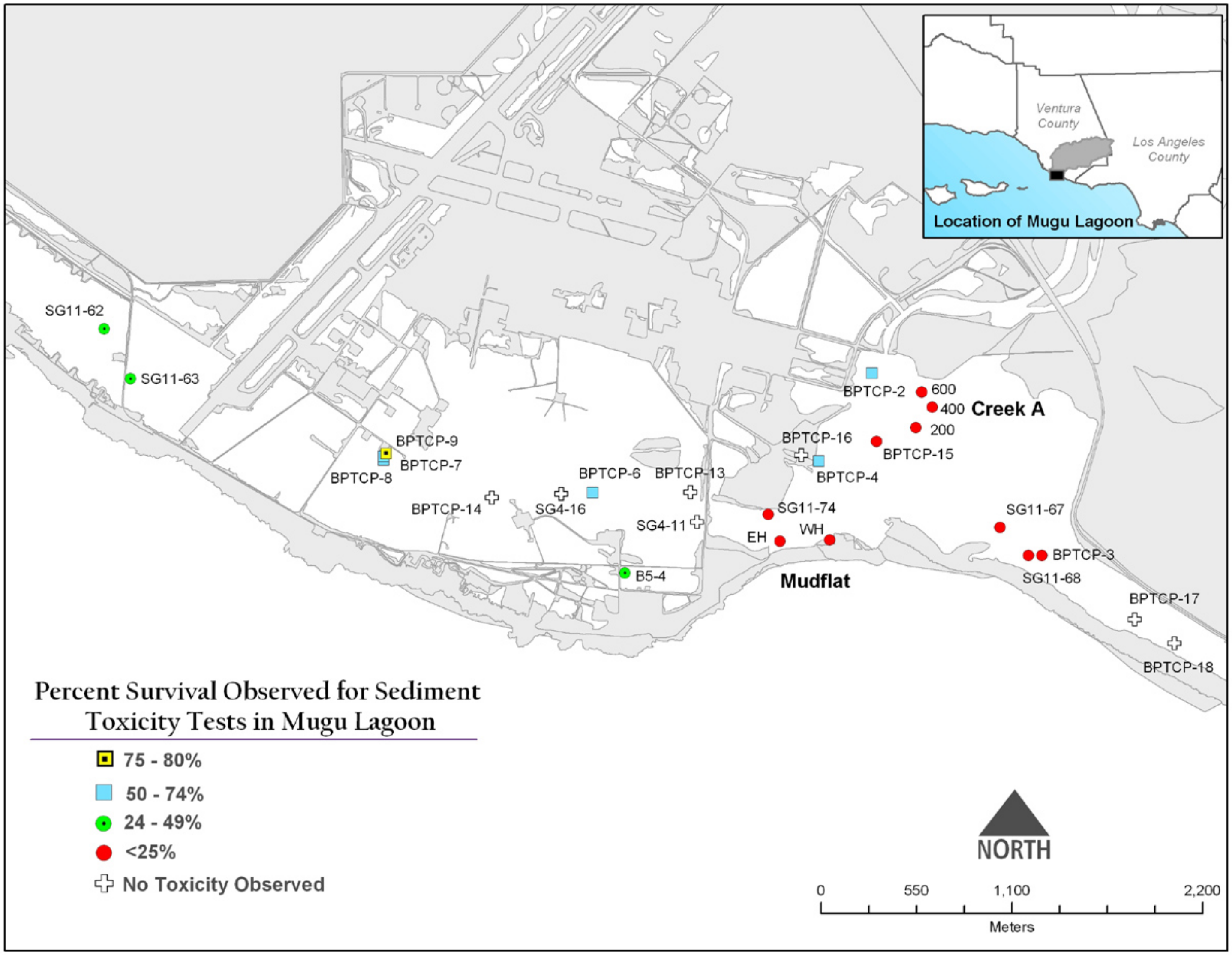

Figure 1. Mugu Lagoon Sediment Toxicity Results

Table 2. Summary of BPTCP Sediment Toxicity Testing

Station	Date	*Eohaustorius estuarius* Mean % Survival	*Rhepoxynius abronius* Mean % Survival
Mugu Lagoon	1/12/93	**66***	N/A
Mugu/Entrance	1/12/93	N/A	**14***
Mugu/Main Lagoon	1/12/93	N/A	**68***
Mugu/Western Arm	1/12/93	N/A	**64***
Mugu/Entrance – Rep 1	4/14/94	N/A	51*
Mugu/Entrance – Rep 2	4/14/94	N/A	69*
Mugu/Entrance – Rep 3	4/14/94	N/A	78*
West Mugu Lagoon – A1	2/6/97	87	N/A
West Mugu Lagoon – A2	2/6/97	89	N/A
Central Mugu Lagoon – B1	2/6/97	17*	N/A
Central Mugu Lagoon – B2	2/6/97	85	N/A
East Mugu Lagoon – C1	2/6/97	78	N/A
East Mugu Lagoon – C2	2/6/97	84	N/A

N/A= Not Analyzed
Bold = Basis for 303(d) listing
* = significantly different from the control at the 95% confidence level and less than the threshold based on the 90th percentile Minimum Significant Difference (MSD)

NAWS and NBVC Studies

Sediment samples were collected and analyzed for toxicity in 1994 under the Phase I Remedial Investigation (RI) for the NAWS at Point Mugu. Samples were collected at stations within Sites 2, 4, and 5. Site 2 is located at the southern end of South Mugu Road which transects the entire site; Site 4 is just North of the Lagoon; and Site 5 is located on the southern side of the western arm of Mugu Lagoon. As shown in Table 3, with the exception of lower survival of *Ampelisca* (42%) observed at Site 5 and *Eohaustorius* (59% and 55%) at Site 2 amphipod (*Ampelisca and Eohaustorius*) survival and reburial did not show significant differences when compared to control organisms. Polychaete (*Neanthes*) survival was not impacted at any sites and growth was effected only at one Site 2 location. Samples collected at Site 2 represented low marsh and mudflat sediments. Coordinates were not available for this site location and therefore could not be plotted on Figure 1. Because sediment concentrations of phenanthrene, DDT, chlordane, dieldrin, PCBs, and cadmium exceeded sediment screening values (i.e. minimal effects–low values (ERLs)) and toxicity was observed during the 1994 investigation, a validation study was conducted in 1997.

The validation study compared sediment chemistry and toxicity at several locations within Site 11 to reference sites adjacent to Site 11. Site 11 includes Mugu Lagoon and all of the drainage ditches in the installation. Reference sites were utilized in this study to account for potential effects from upstream sources and/or effects of sediment texture on the results of the bioassays. Toxicity results showed that Site 11 sites were not statistically different from the reference sites. Site 11 sites and reference sites where less than 50% survival was observed are plotted on Figure 1 and percent survival for all Site 11 sites and reference sites is shown graphically in Figure 2. Additionally, there were no strong trends or correlations between amphipod survival percentages and sediment parameters such as percent fines, percent moisture, sulfides, or ammonia (Tetra Tech, 2000).

Table 3. Summary of Navy Toxicity Data Collected for the RI and ERA

Station	Date	*Ampelisca*	*Eohaustorius estuarius*		*Neanthes*	
		Mean % Survival	Mean % Survival	Mean % reburial	Mean % Survival	Mean weight (mg)
Site 2 (SG2-1)	Feb-1994	82	N/A	N/A	92	0.5*
Control 101/102 Control 35/36	Feb-1994 Feb-1994	88/92 --	-- --	-- --	-- 96/80	-- 0.84/0.54
Site 2 (SG11-7)	Feb-1994	N/A	59*	96	96	0.83
	Feb-1994	N/A	55*	93	92	0.47
Control 203	Feb-1994	--	98	96	--	--
Control 200/201	Feb-1994	--	--	--	100/100	0.49/0.41
Site 4 (SG4-11)	Feb-1994	83[a]	N/A	N/A	80[b]	1.92[b]
Site 4 (SG4-16)	Feb-1994	81[a]	N/A	N/A	88[b]	0.41[b]
Site 5 (B5-4)	Feb-1994	42*[a]	N/A	N/A	80	0.7
Control 64/65	Feb-1994	--	--	--	32/96	0.56/0.9
Site 11 (SG11-69)[b]	Dec-1997	64	N/A	N/A	N/A	N/A
Site 11 (SG11-70)[b]	Dec-1997	51	N/A	N/A	N/A	N/A
Site 11 (SG11-71)[b]	Dec-1997	78	N/A	N/A	N/A	N/A
Site 11 (SG11-72)[b]	Dec-1997	91	N/A	N/A	N/A	N/A
Site 11 (SG11-73)[b]	Dec-1997	71	N/A	N/A	N/A	N/A
Site 11 (SG11-74)[b]	Dec-1997	14	N/A	N/A	N/A	N/A
Site 11 (SG11-75)[b]	Dec-1997	89	N/A	N/A	N/A	N/A
Site 11 (SG11-76)[b]	Dec-1997	61	N/A	N/A	N/A	N/A
Reference Area						
SG11-61[b]	Dec-1997	68	N/A	N/A	N/A	N/A
SG11-62[b]	Dec-1997	44	N/A	N/A	N/A	N/A
SG11-63[b]	Dec-1997	39	N/A	N/A	N/A	N/A
SG11-64[b]	Dec-1997	58	N/A	N/A	N/A	N/A
SG11-65[b]	Dec-1997	56	N/A	N/A	N/A	N/A
SG11-66[b]	Dec-1997	65	N/A	N/A	N/A	N/A
SG11-67[b]	Dec-1997	14	N/A	N/A	N/A	N/A
SG11-68[b]	Dec-1997	10	N/A	N/A	N/A	N/A

* = significantly different from the controls at the 95% confidence level.
[a] Corresponding controls are Control 101 and Control 102. [b] Control data not provided.

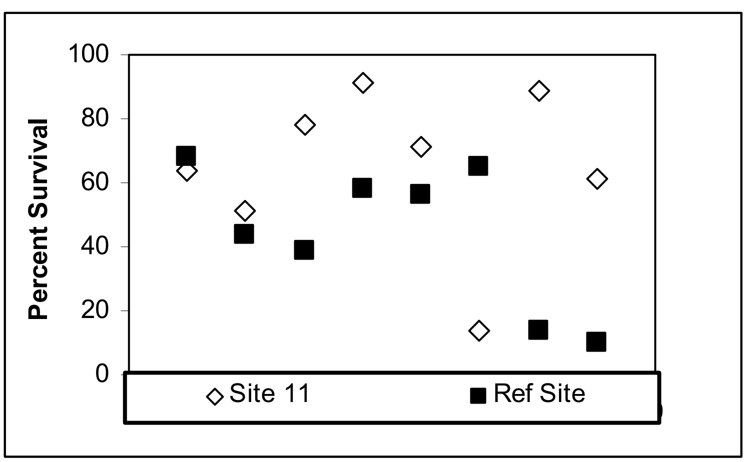

Figure 2. ***Ampelisca*** **Percent Survival at Site 11 Sites and Reference Sites**

Sediment samples were analyzed for pesticides, PCBs, total metals, and phenols. Sediment samples for chemical analysis were not collected at the same locations (co-located) for toxicity samples during the 1994 remedial investigation but co-located toxicity and sediment samples were collected for the additional testing that was conducted in 1997. Although toxicity was not observed relative to reference sites, samples from both the study sites and reference sites showed toxicity at some locations. However, based on the results provided in the study reports (Tetra Tech 2000, 2003) it was not possible to determine which sites showed toxicity when compared to test control organisms. As discussed in the following section sediment chemistry results were compared to toxicity benchmark values to assess possible causes of observed sediment toxicity at these sites.

Collection of sediment samples for these studies differed from the BPTCP and UCLA studies in that sediment was collected at a depth from 0 – 0.5 feet, therefore representing a deeper core sample than the surficial samples collected from the top 2 centimeters in the other studies.

UCLA Study

Sediment toxicity tests were performed on sediment samples collected from four sites in each of two tidal creeks (Creek A and Creek C) located within the central marsh at 0, 200, 400, and 600 meters from the creek mouths. Additionally, in the mudflat area sites were sampled at 0, 100, and 200 meters along two transect lines. One transect was at the mean low tide line and the other at the mean high tide. Benthic and sediment cores (22 cm^2, 6 cm deep) were collected and one liter of aerobic sediment was collected within 30 cm of the cores for toxicity, chemistry (metals, pesticides, PCBs, and PAHs), porewater salinity, dissolved ammonia, and pH measurements. The oxygenated layer of sediment was collected in order to minimize factors that may impact toxicity and contaminant results due to oxidation of anoxic sediments. The sediment was collected by scraping the surface sediment down to the anaerobic layer (1-2 cm).

Results are provided in Table 4 and indicate low survival of organisms at several locations; however, the study report did not provide information regarding the statistical significance of these differences from controls. These results are compared to sediment chemistry concentrations in the following section. Sites where less than 50% survival was observed are plotted on Figure 1.

Table 4. Summary of Toxicity Data Collected by UCLA

Station	Date	***Eohaustorius*** **Mean % Survival**
Creek A (A0)	Feb-2001	66.3
Creek A (A200)	Feb-2001	9.2
Creek A (A400)	Feb-2001	0
Creek A (A600)	Feb-2001	0
Creek C (C0)	Feb-2001	67.5
Creek C (C200)	Feb-2001	51.9
Creek C (C400)	Feb-2001	80
Creek C (C600)	Feb-2001	62.5
Mudflat EH	Feb-2001	28.8
Mudflat EL	Feb-2001	55
Mudflat MH	Feb-2001	60
Mudflat WL	Feb-2001	68.8
Mudflat WH	Feb-2001	21.3

Evaluation of Existing Toxicity Data

For each of the studies in which sediment chemical analysis was performed, sediment chemical concentrations were compared to published guideline values including minimal effects-low (ERL), effects range-median (ERM), and the probable effects level (PEL). The guideline values used were derived from a wide variety of studies on invertebrates and marine and estuarine sediments, including the National Oceanic and Atmospheric Association database. It should be noted that these values were developed as informal, interpretive tools. The guidelines are not promulgated as regulatory criteria or standards, and are not intended as cleanup or remediation targets, discharge attainment targets, or as pass-fail criteria for dredged material disposal decisions or any other regulatory purpose.

Evaluations performed for BPTCP, NBVC study, and UCLA study results all utilized the same ERL and ERM values as listed in Table 5. PEL values provided in Table 5 were used by the BPTCP but not the other studies, for purposes of this evaluation other study results were compared to the PEL values used by the BPTCP.

Table 5. Sediment Screening Levels

CONSTITUENT	PEL	ERL	ERM
Total PCB (ug/kg – dry weight)	188.79	22.70	180.0
PAH (ug/kg – dry weight)			
Acenaphthene	88.90	16.00	500.0
Acenaphthylene	127.89	44.00	640.0
Anthracene	245.00	85.30	1100.0
Fluorene	144.35	19.00	540.0
2-methylnapthalene	201.28	70.00	670.0
Naphthalene	390.64	160.00	2100.0
Phenanthrene	543.53	240.00	1500.0
Total LMW-PAHs	1442.00	552.00	3160.0
Benz(a)anthracene	692.53	261.00	1600.0
Benzo(a)pyrene	763.22	430.00	1600.0
Chrysene	845.98	384.00	2800.0
Dibenz(a,h)anthracene	134.61	63.40	260.0
Fluoranthene	1493.54	600.00	5100.0
Pyrene	1397.60	665.00	2600.0
Total HMW-PAHs	6676.14	1700.00	9600.0
Total PAHs	16770.54	4022.00	44792.0
Pesticides (ug/kg - dry weight)			
p,p'DDE	374.17	2.20	27.0
p,p'DDT	4.77		
Total DDT	51.70	1.58	100.0/g.o.c.
Lindane	0.99		
Chlordane	4.79	2.00	6.0
Dieldrin	4.30		8.0
Endrin			45.0
Metals (mg/kg - dry weight)			
Arsenic	41.60	8.20	70.0
Antimony		2.00	25.0
Cadmium	4.21	1.20	9.6
Chromium	160.40	81.00	370.0
Copper	108.20	34.00	270.0
Lead	112.18	46.70	218.0
Mercury	0.70	0.15	0.7
Nickel	42.80	20.90	51.6
Silver	1.77	1.00	3.7
Zinc	271.00	150.00	410.0

The ERL represents the lower 10th percentile of ranked data where chemical concentration was associated with an effect; concentrations below the ERL are rarely expected to cause adverse biological effects to invertebrates. The ERM expresses the 50th percentile of ranked data and the level above which effects are expected to occur. Therefore, effects are occasionally expected to occur when chemical concentrations fall between the ERL and ERM. ERM quotients (ERM-Q) can be calculated to allow for a simple comparison between observed chemical concentrations and guideline values developed for that chemical. To derive an ERM-Q the concentration of each chemical is divided by its respective ERM value to get a quotient. In addition, quotient values for multiple chemicals can be averaged to get a mean ERM-Q to screen samples for potential effects of chemical mixtures. Quotient values greater than 1 indicate that the chemical in that sample exceeded its guideline value, and is likely to be associated with biological effects.

A discussion of the relationship between observed toxicity and measured sediment concentrations for each study is provided below.

BPTCP

As indicated in Table 6, there is not enough corresponding sediment data to interpret potential causes of toxicity for the samples in which toxicity was observed with the exception of the Mugu/Entrance and Central Mugu Lagoon-B1 stations. No sediment concentrations were above screening values at the Mugu Entrance station. At the Central Lagoon station elevated concentrations of total chlordane and total PCBs were observed. Additionally, at some sites samples were significantly toxic using a t-test but were not toxic relative to the MSD value (see Table 2). For these sites sediment chemistry indicates that some biological effect may potentially be caused by total chlordane and total PCBs, and additionally zinc for the East Mugu Lagoon – C1 station. The BPTCP reported that chemical and biological results at Mugu Lagoon sites were variable. Although individual pesticides sometimes exceeded guideline values ERM quotients were low (BPTCP, 1998).

NAWs and NBVC

In sediment samples collected for the IR in 1994, concentrations of phenanthrene, DDT, chlordane, dieldrin, PCBs, and cadmium exceeded ERLs. However, because sediment samples collected for the IR in 1994 for toxicity were not collected at the same sites and times as sediment samples for chemical analysis, meaningful evaluation of the relationship between chemical concentrations and the toxicity observed could not be performed.

As mentioned previously, sediment samples collected under the validation study in 1997 were not significantly toxic when compared to reference site results. The report available for these data did not indicate toxicity relative to control organisms but only compared toxicity at regular sites to results from reference sites. However, in an effort to identify potential causes of sediment toxicity, tests with survival less than 50% were evaluated against sediment chemistry results and sediment biological effects values.

Table 6. Sediment Chemistry and Toxicity Comparison for BPTCP Data

Site	*Eohaustorius* toxicity (yes/no)	*Rhepoxynius* toxicity (yes/no)	Sediment Toxicity Benchmark Evaluation[a]			
			Zinc	Total Chlordane	Dieldrin[b]	Total PCBs
Mugu Lagoon	Yes	NA	NA	NA	NA	NA
Mugu/Entrance	Yes	Yes	<ERL	<ERL	<ERM	<ERL
Mugu/Main Lagoon	NA	Yes	NA	NA	NA	NA
Mugu/Western Arm	NA	Yes	NA	NA	NA	NA
West Mugu Lagoon – A1	NA	No[c]	<ERL	>ERL <ERM	<ERM	>ERL <ERM
West Mugu Lagoon – A2	NA	No[c]	<ERL	>ERL <ERM	<ERM	>ERL <ERM
Central Mugu Lagoon – B1	NA	Yes	<ERL	>ERM	<ERM	>ERL <ERM
Central Mugu Lagoon – B2	NA	No[c]	NA	>ERM	<ERM	>ERL <ERM
East Mugu Lagoon – C1	NA	No[c]	>ERL <ERM	>ERM	<ERM	>ERL <ERM
East Mugu Lagoon – C2	NA	No[c]	<ERL	>ERM	<ERM	>ERL <ERM

[a] Below the ERL biological effects not expected; between the ERL and ERM biological effects expected; effects expected above the ERM.
[b] Evaluated with ERM value only because an ERL is not available.
[c] Was toxic with t-test but not relative to the MSD value.

Sediment samples collected during the validation study were analyzed for pesticides, PAHs, and metals. Table 7 includes the constituents that were detected above ERL, ERM, or PEL values. All other constituents were not detected above these screening values. Some constituents; archlors, gamma-BHC, and chlordane; were not included in the table because detection limits were above the screening values so an accurate evaluation of these constituents could not be performed. As indicated in Table 7, sediment values for DDE (at 2 sites), cadmium (at 1 site), copper (at 1 site), lead (at 1 site), nickel (at 4 sites), and zinc (at 1 site) were between the ERL and ERM for sites with survival rates less than 50%. DDD (at 3 sites) and DDT (at 2 sites) concentrations were above PELs for sites with less than 50% survival. To further compare sediment concentrations to mortality the data were ranked according to percent survival. This comparison indicated that no distinct patterns between chemistry and toxicity were discernable from these data.

It is important to note that trace metals toxicity is dependant on general sediment quality data (e.g. acid volatile sulfide, organic carbon, percent fines). Comparison of the metals analyzed during the validation study to sediment quality parameters indicated a strong trend between concentration and percent moisture.

UCLA
Information regarding the significance of toxicity compared to control organisms was not provided in the draft report (Anghera, 2003), however several tests had low survival percentages. Complete mortality was observed at two sites on Creek A; total DDT, copper, cadmium, and arsenic (1 site only) sediment concentrations at these sites were between ERL and ERM values indicating possible biological effects associated with these constituents. At one site on Creek A 9.2 percent survival was observed and total DDT and cadmium sediment concentrations were between the ERL and ERM for this sample. Two high tide mudflat samples demonstrated low survival 28.8 percent and 21.3 percent and total DDT and cadmium sediment concentrations were between the ERL and ERM for both sites and copper at one site. Although some screening values were exceeded all ERM-Q values were below 1.

Conclusions

Based on evaluation of existing sediment data identified for Mugu Lagoon, significant toxicity to amphipods has been observed at several locations. None of the referenced studies conducted TIEs as such no constituents could be identified as contributing to the toxicity observed in these samples. However, in the interest of identifying potential causes of observed toxicity to assist in future monitoring efforts, the comparison of available sediment chemistry data collected at these same sites indicated several possible constituents that may be responsible for the observed toxicity. Also, a more in-depth analysis involving sediment quality characteristics would be required to determine potential metals toxicity. Following is a summary of these constituents for each of the studies included in this evaluation.

BPTCP:	total chlordane, total PCBs, and zinc
NAWS & NBVC:	DDD, DDT, DDE, cadmium, copper, lead, nickel, and zinc
UCLA:	DDT, copper, cadmium, and arsenic

In addition, based on the results of the reviewed studies it was possible to identify constituents that were not detected above screening values and therefore provide some evidence that these constituents may not need to be addressed. PAHs were analyzed during all studies but were not detected in any study above sediment screening values. No pesticides for which screening values were available exceeded these values except DDT, DDD, DDE, and total chlordane; however, dieldrin, gamma-BHC, chlordane, and several archlors analyzed by the NBVC validation study had detection limits above screening values. Other metals that were analyzed and not detected above screening values include antimony, chromium, mercury, and silver.

Table 7. Sediment Chemistry and Toxicity Comparison for NAWs and NBVC Studies

Sample Location	Sample Date	Amphipod (*Ampelisca*) Survival (%)	DDD	DDE	DDT	Arsenic	Cadmium	Copper	Lead	Nickel	Zinc
Effects Range-Low (ERL)				2.2		8.2	1.2	34	46.7	20.9	150
Effects Range-Median (ERM)				27		70	9.6	270	218	51.6	410
Probable Effect Level (PEL)			7.81	374.2	4.77	41.6	4.21	108.2	112.2	42.8	271
SG11-68	Dec-97	10	**J 18**	***57***	**30**	4.1	<0.52	14.7	6.5	16.7	44.2
SG11-67	Dec-97	14	J 1.9	*9.6*	J 1.7	5.9	<0.73	18.5	8.3	*22*	56.5
SG11-74	Dec-97	14	**11**	***42***	**9.9**	5.9	<0.83	19.2	9.6	*22*	67.3
SG11-63	Dec-97	39	**J 11**	***41***	< 14	5.1	*J 1.7*	*42.3*	32.1	*36.8*	*152*
SG11-62	Dec-97	44	1.2	*7.6*	J 0.48	7.8	<0.38	28.1	*168*	*28*	98.2
SG11-70	Dec-97	51	5.7	*14*	J 2.6	*10.9*	*J 1.5*	*36.2*	12.8	*34.2*	91.2
SG11-65	Dec-97	56	J 2.7	*18*	J 4.2	*16.6*	**7**	32.2	11.9	***63.3***	107
SG11-64	Dec-97	58	J 6.4	***64***	**J 6.2**	*8.7*	*J 1.9*	*37*	22.7	*34*	128
SG11-76	Dec-97	61	J 0.76	< 0.58	< 0.58	5	<1.1	24.9	10.5	*24.8*	76.8
SG11-69	Dec-97	64	J 4.3	***36***	J 3.8	7.4	*J1.3*	26.3	17.3	*28.6*	84.7
SG11-66	Dec-97	65	J 3.2	*14*	J 2.9	4.3	<0.44	12.5	6.7	14.3	39.7
SG11-61	Dec-97	68	< 1.3	< 1.3	<1.3	7.2	<0.57	*38.5*	41	*J 30.8*	95.9
SG11-73	Dec-97	71	J 2.1	*12*	J 1.5	5.5	<0.75	18.3	9.1	*21.4*	59
SG11-71	Dec-97	78	7.1	***33***	**J 5.3**	7.3	<0.87	24	12.1	*25.1*	74.2
SG11-75	Dec-97	89	< 9.4	***29***	< 9.4	4.3	<0.44	15.7	8.2	19.2	53.8
SG11-72	Dec-97	91	**J 9**	***37***	**J 6.4**	7	*J 1.2*	*39.7*	12.2	*37.9*	89.4

Bold data are higher than the PEL
Italicized data are between the ERL and the ERM
< = below detection limit

Table 8. Sediment Chemistry and Toxicity Comparison for UCLA Data[a]

Site		Metals (mg/kg)				Organics (mg/kg)		ERM-Q	Amphipod Mean Survival (%)
		Arsenic	Silver	Cadmium	Copper	DDT	Total DDT		
ERL		8.2	1.0	1.2	34.0	NA	1.58	NA	NA
ERM		70.0	3.7	9.6	270.0	4.7[b]	46.1		
Creek A	A0	5.4 (0.8)	0.23 (0.1)	1.1 (0.1)	24.6 (4.5)	0.0 (0.0)	55.1 (4.2)	0.3	66.3 (6.1)
	A200	7.2 (0.6)	0.2 (0.0)	1.2 (0.1)	31.9 (3.4)	4.3 (0.8)	126.7 (10.9)	0.5	9.2 (9.2)
	A400	7.7	0.1	1.2	34.7	4.0	121.1	0.5	0.0
	A600	8.4	0.2	1.7	44.6	4.4	64.1	0.4	0.0
	Total[c]	7.2 (0.6)	0.2 (0.0)	1.3 (0.1)	34.0 (0.1)	3.2 (1.1)	91.8 (18.7)	0.4 (0.0)	20.7 (14.1)
Creek C	C0	5.7	0.2	0.5	15.9	0.0	26.8	0.2	67.5
	C200	8.1 (1.7)	0.2 (0.1)	0.7 (0.1)	17.8 (3.2)	1.5 (0.6)	46.7 (5.1)	0.2	51.9 (10.9)
	C400	11.5	0.3	1.4	39.5	0.0	29.6	0.3	80.0
	C600	5.6	0.2	0.7	16.2	0.0	19.8	0.1	62.5
	Total[c]	7.7 (1.4)	0.2 (0.0)	0.8 (0.2)	22.4 (5.7)	0.4 (0.4)	30.7 (5.7)	0.2 (0.0)	72.6 (14.1)
Mudflat	EH	6.1 (0.4)	0.3 (0.1)	1.4 (0.2)	31.4 (1.7)	0.0 (0.0)	67.3 (3.5)	0.3	28.8 (3.5)
	EL	6.0	0.1	1.2	31.8	0.0	66.7	0.3	55.0
	MH	6.8	0.3	1.1	31.8	na	0.0	0.2	60.0
	WL	5.4	0.2	0.9	24.8	0.0	31.3	0.2	68.8
	WH	7.3	0.2	1.4	35.8	0.0	83.4	0.4	21.3
	Total[c]	6.3 (0.3)	0.2 (0.0)	1.2 (0.1)	31.1 (1.8)	0.0	49.8 (15.1)	0.3 (0.0)	41.6 (11.5)

[a] Values in parentheses are standard error (SE)
[b] Probable Effect Level (PEL)
[c] Total value for each area (n=4) calculated from the average value for each site within each area

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Appendix II. Land Use in the Calleguas Creek Watershed by Subcategory

Name (class1,subclass1)	Acres in CCW	% of CCW	Acres of Utilized Land	% of Utilized Land
native veg	103,689.95	47.1%	--	--
urban	52,723.13	24.0%	52,723.13	47.1%
lemons	17,647.92	8.0%	17,647.92	15.8%
avocados	7,913.95	3.6%	7,913.95	7.1%
strawberries	5,261.21	2.4%	5,261.21	4.7%
peppers	3,048.93	1.4%	3,048.93	2.7%
beans(green)	2,938.90	1.3%	2,938.90	2.6%
celery	2,643.34	1.2%	2,643.34	2.4%
no data	2,491.16	1.1%	--	--
misc truck	2,307.12	1.0%	2,307.12	2.1%
flowers,nursery,xmas tree	2,295.47	1.0%	2,295.47	2.1%
onions, garlic	1,520.59	0.7%	1,520.59	1.4%
turf farms	1,424.69	0.6%	1,424.69	1.3%
golf course	1,276.71	0.6%	1,276.71	1.1%
lawn area, irr	1,132.84	0.5%	1,132.84	1.0%
mixed(4)	1,091.30	0.5%	1,091.30	1.0%
lettuce	1,039.00	0.5%	1,039.00	0.9%
citrus (misc)	846.87	0.4%	846.87	0.8%
melon,squash,cuc	818.42	0.4%	818.42	0.7%
riparian	815.14	0.4%	--	--
oranges	676.46	0.3%	676.46	0.6%
corn (field and sweet)	650.51	0.3%	650.51	0.6%
truck crops (misc)	626.95	0.3%	626.95	0.6%
water	610.72	0.3%	--	--
broccoli	512.11	0.2%	512.11	0.5%
misc field	482.23	0.2%	482.23	0.4%
cabbage	464.71	0.2%	464.71	0.4%
barley	373.14	0.2%	373.14	0.3%
tomatoes	346.09	0.2%	346.09	0.3%
mixed pasture	340.96	0.2%	340.96	0.3%
livestock feed lots	321.04	0.1%	321.04	0.3%
barren	290.32	0.1%	--	--
bush berries	244.12	0.1%	244.12	0.2%
cole crops	217.13	0.1%	217.13	0.2%
cauliflower	177.42	0.1%	177.42	0.2%
spinach	119.46	0.1%	119.46	0.1%
grain (misc)	105.67	0.0%	105.67	0.1%
sudan	73.79	0.0%	73.79	0.1%
artichoke	66.99	0.0%	66.99	0.1%
idle	121.63	0.1%	--	--
carrots	53.97	0.0%	53.97	0.0%
vinyard	41.14	0.0%	41.14	0.0%
farmsteads	38.42	0.0%	38.42	0.0%
pasture (misc)	27.52	0.0%	27.52	0.0%
pistachios	11.61	0.0%	11.61	0.0%
poultry	9.75	0.0%	9.75	0.0%
grapefruit	9.68	0.0%	9.68	0.0%
walnuts	8.19	0.0%	8.19	0.0%
misc subtropical fruit	6.63	0.0%	6.63	0.0%
wheat	5.76	0.0%	5.76	0.0%
cemetery, irr	5.47	0.0%	5.47	0.0%
total =	**219,966.22**	**100.0%**	**111,947.30**	**100.0%**