CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
SAN DIEGO REGION

"TECHNICAL"
TOTAL MAXIMUM DAILY LOAD (TMDL)
FOR THE PESTICIDE DIAZINON
IN CHOLLAS CREEK
SAN DIEGO COUNTY, CALIFORNIA

APRIL 28, 2000

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Executive Summary

Since 1994, storm water flows in Chollas Creek have been found to be toxic in almost all toxicity tests performed using the water flea *Ceriodaphnia*. Consequently, Chollas Creek has not met the applicable water quality objective for toxicity. The repeated toxicity of Chollas Creek storm water indicates likely adverse affects to aquatic organisms, which means that "warm freshwater habitat" and "wildlife habitat," two of the beneficial uses of Chollas Creek, have not been protected. Results from a toxicity identification evaluation (TIE) indicate that the insecticide diazinon in Chollas Creek storm water has caused the toxicity to the water flea *Ceriodaphnia*. Since the toxicity has been caused by diazinon, Chollas Creek has not met the applicable water quality objective for pesticides.

The goal of this Total Maximum Daily Load (TMDL) is to reduce diazinon concentrations in Chollas Creek to meet the water quality objectives for toxicity and pesticides in Chollas Creek. Since there are no applicable numeric water quality objectives for toxicity or for diazinon, this TMDL is based on numeric targets for diazinon that are expected to result in attainment of the narrative water quality objectives for toxicity and pesticides. The numeric targets are the same as the Department of Fish and Game freshwater Water Quality Criterion (WQC) for protection of freshwater aquatic organisms from diazinon. Meeting these numeric targets is also expected to result in protection (from diazinon) of the "warm freshwater habitat" and "wildlife habitat" beneficial uses of Chollas Creek.

Diazinon is a widely used organophosphate insecticide that is a common pollutant in urban storm water runoff and dry weather flows. Diazinon used in the Chollas Creek watershed consists of <u>reported</u> use and <u>unreported</u> use. Both reported and unreported uses of diazinon in the watershed were estimated using available data. Structural pest control was estimated to be the predominant <u>reported</u> use of diazinon in the watershed. <u>Unreported</u> use of diazinon was estimated to exceed <u>reported</u> use in the watershed. In the absence of evidence indicating otherwise, runoff is believed to be the primary pathway by which diazinon enters Chollas Creek.

Due to the difficulty of determining appropriate mass emission rate allocations, this TMDL establishes concentration-based allocations. The concentration-based allocations for all categories of diazinon sources are the same, and are the same as the numeric targets.

Implementation of this TMDL is likely to involve one or the other or some combination of two basic approaches. The first approach would involve legal restrictions on the availability and use of diazinon and/or economic disincentives to diazinon use. The second approach would involve education and outreach with the aim of reducing diazinon use, changing the manner in which diazinon is used, and preventing improper disposal of diazinon. In order for either approach (or any combination thereof) to be effective, similar measures are also likely to be necessary for other pesticides (e.g., chlorpyrifos). In the absence of such measures, reductions in diazinon use may be offset by increased use of other pesticides, with the result of continued toxicity in aquatic systems.

Problem Statement

What is the problem?

Since 1994, Chollas Creek storm water flows have been found to be toxic in almost all toxicity tests performed using the water flea *Ceriodaphnia*. Consequently, Chollas Creek has not met the applicable water quality objective for toxicity. Toxicity testing is an accepted method for assessment of the potential impact of complex mixtures of pollutants (such as urban storm water runoff) on aquatic life in receiving waters. The water flea *Ceriodaphnia* is an approved test organism for examination of freshwater samples. The repeated toxicity of Chollas Creek storm water to the water flea *Ceriodaphnia* indicates likely adverse affects to aquatic organisms, which means that “warm freshwater habitat” and “wildlife habitat,” two of the beneficial uses of Chollas Creek, have not been protected.

A toxicity identification evaluation (TIE) has been conducted to determine the cause of the toxicity in Chollas Creek storm water. Results from the TIE indicate that the insecticide diazinon has caused the toxicity to the water flea *Ceriodaphnia*. Since the toxicity has been caused by diazinon, Chollas Creek has not met the applicable water quality objective for pesticides.

Diazinon is a widely used organophosphate insecticide that is a common pollutant in urban storm water runoff and dry weather flows. Diazinon-induced toxicity in storm water has been found in the San Francisco Bay area, California (Alameda County Flood Control and Water Conservation District 1997); in the Sacramento-San Joaquin Valley, California (Menconi and Cox 1994) in the Castro Valley Creek watershed in Alameda County, California (Hansen et al. 1994); in Crandall Creek and the Demonstration Urban Stormwater Treatment (DUST) Marsh system in Alameda County, California (Woodward-Clyde Consultants 1995); in urban creeks (e.g., Arcade Creek and Elder Creek) in Sacramento, California (Bailey et al 2000); and in urban creeks (e.g., Mosher Slough) in Stockton, California (Bailey et al. 2000). In studies in Alameda County, California, diazinon was often detected in water and sediments of urban creeks throughout the year, not only during wet weather (URS Greiner Woodward Clyde 1999). Diazinon has been found in dry weather flows in Alameda County, California creeks (Katznelson and Mumley 1977). Dry weather samples collected in urban creeks in Sacramento, California (e.g., Arcade Creek) also contained diazinon.”(Katznelson and Mumley 1977).

Creek and Watershed Description

Chollas Creek is an urban creek with highly variable flows. The highest flow rates are associated with storm events. During dry weather, there are often extended periods of no surface flows in the creek, although pools of standing water may be present. Much of the creek has been channelized and concrete lined, but some sections of earthen creek bed remain. The mouth of the creek is located on the eastern shoreline of the central portion of San Diego Bay.

The watershed of Chollas Creek encompasses 16,273 acres. The area of the north fork of the watershed (9,276 acres) is somewhat larger than that of the south fork (6,997 acres).

As Table 1 indicates, the watershed is highly urbanized. Land use is predominantly residential, with some commercial and industrial use. A significant portion of the watershed consists of roadways. The remaining land in the watershed is open space. Portions of the cities of San Diego, Lemon Grove, and La Mesa are located within the watershed. A small portion of the watershed consists of "tidelands" immediately adjacent to San Diego Bay. Some of this tideland area is under the jurisdiction of the San Diego Unified Port District; the remainder is under the jurisdiction of the United States Navy.

The annual average rainfall in the Chollas Creek watershed is about 9 inches (URS Greiner Woodward Clyde 1999). Rainfall statistics for the San Diego International Airport (a.k.a. Lindbergh Field, located about 4 miles northwest of Chollas Creek, near San Diego Bay) indicate that an average of 18 storms occur each year (URS Greiner Woodward Clyde 1999).

Table 1
Land Use in the Chollas Creek Watershed
(Woodward-Clyde International-Americas, 1998)

Land Use	Percent of Total Area (Entire Watershed)	Percent of Sampled Area (North Fork Watershed)
Residential	67%	62%
Commercial	5%	9%
Industrial	7%	10%
Roadways	4%	5%
Open Space	16%	14%

Sampling History in the Watershed

<u>Municipal Storm Water NPDES Permit Sampling</u>

Monitoring of storm water in Chollas Creek began in the 1993-94 rainy season pursuant to the municipal storm water National Pollutant Discharge Elimination System (NPDES) permit for San Diego County. Each rainy season, storm water samples are collected from two or three storms at a station located on the north fork of Chollas Creek, upstream of the confluence of the north and south forks of the creek, near the intersection of 33rd and Durant Streets. This location was selected in order to avoid tidal influence. Runoff from approximately 57% of the entire watershed is sampled at this monitoring site. Storm water samples collected at this location are considered to be representative of runoff from the entire watershed because the land use mix in the north fork portion of the watershed is similar to the land use mix of the entire watershed, as Table 1 indicates.

Since the 1993-94 rainy season, storm water samples have been analyzed for general physical constituents, nutrients, biochemical oxygen demand, chemical oxygen demand, bacteriological constituents, organic constituents, and total recoverable metals. Some samples are also analyzed for dissolved metals. Toxicity testing began with the 1994-95 rainy season and is conducted using the fish commonly known as the fathead minnow (*Pimephales promelas*) and the water flea (*Ceriodaphnia dubia*). Testing using the fathead minnow has shown little, if any, adverse effect (URS Greiner Woodward Clyde 1999). In contrast, every test using the water flea has found toxicity, as indicated by mortality (URS Greiner Woodward Clyde 1999). Storm water toxicity testing in the San Francisco Bay area revealed a very similar pattern, where diazinon was discovered to be the major cause of toxicity to the water flea (URS Greiner Woodward Clyde 1999). Chollas Creek storm water flows were not analyzed for diazinon until the 1998-99 rainy season, when concentrations of diazinon ranging from 0.46 µg/l to 0.53 µg/l were found (URS Greiner Woodward Clyde 1999).

Toxicity Identification Evaluation (TIE)
A toxicity identification evaluation (TIE) is a procedure to determine the cause of toxicity. A TIE was conducted to determine the cause of the toxicity in Chollas Creek storm water flows. The TIE was conducted by the Southern California Coastal Water Research Project (SCCWRP) and Ogden Environmental, Energy, and Remediation Division (Ogden) under an agreement between the San Diego Regional Water Quality Control Board (SDRWQCB), the City of San Diego, the San Diego Unified Port District, and the California Department of Transportation (CalTrans). The TIE effort was initiated in March of 1999 and a final report was completed in November 1999 (SCCWRP 1999). Chollas Creek storm water from three storms in 1999 was evaluated in the TIE. The first task was to compare toxic responses of three commonly used test organisms; one freshwater species (the water flea *Ceriodaphnia dubia)* and two marine species (the purple sea urchin *Strongylocentrotus purpuratus* and the mysid shrimp *Mysidopsis bahia*). The salinity of storm water samples tested using the marine species was adjusted to approximate seawater salinity levels. A Phase I TIE was conducted to ascertain the class or group of constituents responsible for the observed toxicity. A Phase II TIE was conducted in an effort to determine the primary constituent(s) responsible for the observed toxicity. A Phase III TIE was conducted to confirm the primary constituent(s).

Water from the first two storms was found to be toxic to the water flea. Water from the third storm was not found to be toxic to the water flea. Water from all three storms was found to be toxic to the purple sea urchin. Water from all three storms was not found to be toxic to the mysid shrimp. The TIE results indicate that the toxicity to the water flea was caused by diazinon, which was found in concentrations from 0.32 µg/l to 0.54 µg/l. Consequently, this TMDL focuses on diazinon. The TIE results also indicate that toxicity to the purple sea urchin was caused by zinc. Work is underway on a separate TMDL for metals (including zinc) in storm water runoff from the Chollas Creek watershed.

Applicable Water Quality Standards

Water quality standards consist of beneficial uses and water quality objectives. The *Water Quality Control Plan for the San Diego Basin (9)* (Basin Plan) (SDRWQCB 1994) specifies water quality standards for all waters in the San Diego region, including Chollas Creek and San Diego Bay. The water quality standards that are applicable to this TMDL are the water quality objectives for toxicity and pesticides in Chollas Creek and the beneficial uses of Chollas Creek that could be adversely affected by toxicity and pesticides.

The following Basin Plan narrative water quality objective for toxicity is applicable to all inland surface waters (including Chollas Creek), enclosed bays (including San Diego Bay) and estuaries, coastal lagoons, and ground waters of the San Diego region.

> "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. Compliance with this objective will be determined by use of indicator organisms, analyses of species diversity, population density, growth anomalies, bioassays of appropriate duration, or other appropriate methods as specified by the Regional Board.
>
> "The survival of aquatic life in surface waters subjected to a waste discharge or other controllable water quality factors, shall not be less than that for the same water body in areas unaffected by the waste discharge or, when necessary, for other control water that is consistent with requirements specified in US EPA, State Water Resources Control Board or other protocol authorized by the Regional Board. As a minimum, compliance with this objective as stated in the previous sentence shall be evaluated with a 96-hour acute bioassay.
>
> "In addition, effluent limits based upon acute bioassays of effluents will be prescribed where appropriate, additional numerical receiving water objectives for specific toxicants will be established as sufficient data become available, and source control of toxic substances will be encouraged."

The following Basin Plan narrative water quality objective for pesticides is applicable to all inland surface waters (including Chollas Creek), enclosed bays (including San Diego Bay) and estuaries, coastal lagoons, and ground waters of the San Diego region.

> "No individual pesticide or combination of pesticides shall be present in the water column, sediments, or biota at concentration(s) that adversely affect beneficial uses. Pesticides shall not be present at levels which will bioaccumulate in aquatic organisms to levels which are harmful to human health, wildlife or aquatic organisms."

The beneficial uses of Chollas Creek (and, for comparison, those of San Diego Bay) specified in the Basin Plan are listed in Table 2.

The occurrence of toxicity in Chollas Creek storm water indicates that the water quality objective for toxicity was not met in Chollas Creek. Since the toxicity was caused by the insecticide diazinon, the water quality objective for pesticides was not met in Chollas Creek. The "warm freshwater habitat" and "wildlife habitat" beneficial uses of Chollas Creek could be adversely affected by toxicity and/or pesticides.

The water flea *Ceriodaphnia* that is used in toxicity tests serves as an indicator or surrogate for the aquatic life in Chollas likely to have been affected by diazinon.

Diazinon concentrations that cause toxicity to the water flea *Ceriodaphnia* may also cause toxicity to other aquatic life, such as aquatic insects. Toxicity of the storm water to aquatic insects or other aquatic life is of concern because the function of the stream for supporting life is reduced. Aquatic insects and other invertebrates are necessary to support and maintain ecosystem balance. Fish, frogs, birds, and other creatures rely on aquatic insects for food. To the extent that diazinon-induced toxicity reduces the abundance or diversity of aquatic insects in Chollas Creek, the food supply of fish, frogs, birds, and other creatures is correspondingly reduced and the “warm freshwater habitat” and “wildlife habitat” beneficial uses of Chollas Creek are impaired.

Table 2
Beneficial Uses of Chollas Creek and San Diego Bay

Beneficial Use	Chollas Creek	San Diego Bay
Industrial service supply		·
Navigation		·
Contact water recreation	☐	·
Non-contact water recreation	·	·
Commercial and sport fishing		·
Preservation of biological habitats of special significance		·
Estuarine habitat		·
Warm freshwater habitat	·	
Wildlife habitat	·	·
Rare, threatened, or endangered species		·
Marine habitat		·
Migration of aquatic organisms		·
Shellfish harvesting		·

· Existing beneficial use
☐ Potential beneficial use

Numeric Targets

Clean Water Act Section 303(d)(1)(C) requires that TMDLs "shall be established at a level necessary to implement the applicable water quality standards...." Numeric targets in this TMDL help to interpret the narrative water quality objectives for toxicity and pesticides and establish the linkage between the TMDL and attainment of the standards.

The goal of this TMDL is to reduce diazinon concentrations in Chollas Creek to meet the water quality objectives for toxicity and pesticides in Chollas Creek. Since the Basin Plan does not contain numeric water quality objectives for toxicity or for pesticides (including diazinon), this TMDL is based on numeric targets for diazinon that are expected to result in attainment of the narrative water quality objectives for toxicity and pesticides. Meeting these numeric targets is also expected to result in protection (from diazinon) of the "warm freshwater habitat" and "wildlife habitat" beneficial uses of Chollas Creek.

Since there is no Basin Plan water quality objective for diazinon, the numeric targets are based on the best documentation available at this time. A Water Quality Criterion (WQC) for protection of freshwater aquatic organisms from diazinon was developed by the California Department of Fish and Game (DFG) (Menconi and Cox 1994). DFG subsequently revised the freshwater WQC for diazinon (Siepmann and Finlayson 2000). The numeric targets listed in Table 3 below are the same as the revised DFG freshwater WQC for diazinon.

Table 3
Numeric Targets for Diazinon in Chollas Creek

Target Type	Target Diazinon Concentration	Averaging Period	Frequency of Allowed Exceedance
Acute	0.08 µg/l	One-hour average	Once every three years on the average
Chronic	0.05 µg/l	Four-day average	Once every three years on the average

For the purpose of evaluating if the numeric targets have been attained, sample results shall be used as follows:

1. If only one sample is collected during the time period associated with the numeric target (e.g., one-hour average or four-day average), the single measurement shall be used to determine attainment of the numeric target for the entire time period.
2. The one-hour average shall be the moving arithmetic mean of grab samples over the specified one-hour period.
3. The four-day average shall apply to flow-weighted composite samples for the duration of a storm, or shall be the moving arithmetic mean of flow weighted 24-hour composite samples or grab samples.

Source Analysis

Diazinon Uses

The purpose of the Source Analysis is to demonstrate that all pollutant sources have been considered, and that loadings from significant sources have been estimated, in order to help determine the degree of loading reductions needed to meet numeric targets and allocate loading allowances among sources.

Diazinon is available in many different formulations (e.g., concentrated liquid, ready-to-use liquid, dust, granules, pressurized sprays, etc.) (Cooper 1996) and is used on a broad spectrum of target pests. Because of the many possible combinations of diazinon formulations, application methods , and target pests, there are many potential pathways by which diazinon could reach surface water. These pathways include runoff from rain, runoff from landscape irrigation, spills, aerial deposition, and/or disposal directly into surface water. It is conceivable that diazinon could enter surface water as a result of use in accordance with label instructions, use not in accordance with label instructions, and/or improper disposal.

In a preliminary experiment done in the Castro Valley Creek watershed, in Alameda County, California, diazinon was applied according to label instructions to control ants on a specific property. Two days later, it rained, and runoff samples were collected within that property during that small rain event. The runoff samples contained up to 1,200,000 ng/l of diazinon (Scanlin and Feng 1997). The City of Palo Alto, California found diazinon concentrations of 100 to 400 ppt in the water in its creeks and discovered that less than a tablespoon of diazinon in “a day’s worth of creek flow” during a storm event was needed to create these concentrations (Cooper 1996). One study suggests that ordinary use (not just misuse or dumping) could release sufficient diazinon into the environment to account for concentrations and toxicity measured in urban storm water runoff (Cooper 1996).

The amount of diazinon actually discharged to surface waters from various sources is not well documented. In order to estimate the relative amounts of diazinon discharged from various sources to Chollas Creek, it was assumed that the amount of diazinon discharged from any use category was proportional to the amount of diazinon used in the watershed in the same use category. The actual relationship between the amount of diazinon used and the amount discharged to surface water is not known at this time.

Diazinon used in the Chollas Creek watershed consists of reported use and unreported use. Both reported and unreported uses of diazinon in the watershed were estimated using available data.

Reported Use of Diazinon

Reported uses include all uses for agriculture, parks, golf courses, rights-of-way, cemeteries, landscape maintenance, and structural pest control. Reporting of home and garden use and most industrial and institutional use is not required. Since 1990, the California Department of Pesticide Regulation (DPR) has required reporting of pesticide use by agriculture and other commercial applicators. DPR compiles all of the reported use information into the Pesticide Use Report database. Pesticide use reports include location, amounts applied, number of acres, and types of crops or places (e.g., structures and roadsides) treated. Commercial applications, including structural fumigation, structural pest control, and turf applications, must also be reported.

Reported diazinon use was calculated using the DPR Pesticide Use Report database for 1997 (DPR 1997b). Pesticide use is generally expressed in terms of the amount of active ingredient, i.e. the component in the pesticide product that actively kills or otherwise controls the target pest. "Diazinon active ingredient" is pure diazinon with no inert substances. "Diazinon product" includes the inert substances that are mixed the diazinon. Expressing pesticide use in terms of active ingredient enables meaningful comparisons of different products to be made. There are a variety of pesticide products that contain different concentrations of active ingredient and inert substances.

Table 4 shows the reported amount of diazinon used in California, as obtained from the "Summary of Pesticide Use Report Data" for 1993, 1994, 1995, 1996, and 1997 (DPR 1993, 1994, 1995, 1996 and 1997a). During this period, the maximum annual reported amount of diazinon used was approximately 2.5 times the minimum annual reported amount of diazinon used.

Table 4
Reported Diazinon Active Ingredient Use in California

Year	Amount Used (pounds)
1993	1,491,709
1994	1,387,854
1995	2,376,882
1996	1,093,120
1997	955,108

Table 5 shows reported diazinon use data for San Diego County as obtained from the Pesticide Use Report database for 1997 (DPR 1997b). This database groups diazinon use into three use categories: agriculture, landscape maintenance, and structural pest control. For each category, the pounds of diazinon active ingredient, pounds of diazinon product, and the number of applications are shown. Diazinon products used for agricultural purposes are generally more concentrated than diazinon products used for structural pest control. Diazinon products used for landscape maintenance are far less concentrated than those used for agricultural or structural pest control purposes. The predominant reported use of diazinon in San Diego County in 1997 was for structural pest control.

Table 5
Reported Diazinon Use in San Diego County (1997)

Use Category	Diazinon Active Ingredient (pounds)	Diazinon Product (pounds)	Number of Applications	Percent of Active Ingredient in Product
Agriculture	2,505	8,022	618	31%
Landscape Maintenance	850	9,205	2,191	9%
Structural Pest Control	24,240	96,730	43,553	25%
Total	**27,595**	**113,957**	**46,362**	

Information on the reported use of diazinon in the Chollas Creek watershed is not available. Therefore, for purposes of this TMDL, SDRWQCB staff estimated such use for each of the use categories identified in Table 5.

A limited survey of diazinon use in the Chollas Creek watershed was conducted by SDRWQCB staff as part of the development of this TMDL. The survey focused on schools, city parks, cemeteries, kennels, the California Department of Transportation (CalTrans), and nurseries. A representative of each agency or facility was telephoned and surveyed on diazinon use. Generally, the telephone contact was followed up with a letter or other written information.

Agencies and facilities were also surveyed on Integrated Pest Management (IPM), which is an ecosystem-based strategy that focuses on long-term control of pests or their damage through a combination of techniques, such as biological control, habitat manipulation, modification of cultural practices, and use of pest resistant plant varieties. In general, IPM provides for pesticide use only after monitoring indicates that, based on established guidelines, pesticides are actually needed. Under IPM, treatments are made with the goal of removing only the target organism, and pest control materials are selected and applied in a manner that minimizes risks to human health, beneficial and non-target organisms, and the environment. The findings of the survey are summarized below.

Schools – The San Diego Unified School District (school district) manages the public schools in the watershed. The school district has had an IPM plan since 1991. Of the approximately 165 public schools managed by the school district, 58 are in the Chollas Creek watershed. The school district reports that it used a total of 70 fluid ounces of a pesticide product containing diazinon from about mid-1997 through about mid-1999. Assuming the density of the diazinon product was the same as that of water (8.34 pounds per gallon) and assuming the diazinon product contained 25% diazinon active ingredient (see Table 5, structural pest control use category), this represents use of less than one pound of diazinon active ingredient per year.

City Parks – Portions of the cities of San Diego, Lemon Grove, and La Mesa are located in the Chollas Creek watershed. These cities own the main parks in the

Chollas Creek watershed. All of these cities report that diazinon is not used on park landscaping. They also report that structural pest control is done by outside contract and no estimates of diazinon use were available. The cities of San Diego and Lemon Grove reported that they were developing an IPM plan. The City of La Mesa reported that it had an IPM plan.

Cemeteries – Four large cemeteries in the Chollas Creek watershed were contacted about diazinon usage: Cypress View-Bonham Brothers Mortuary, Greenwood Memorial Park and Mortuary, Holy Cross Catholic Cemetery and Mausoleum, and Mount Hope Cemetery. A fifth cemetery, the Home of Peace Cemetery, could not be reached. Only one cemetery indicated that it had used diazinon for landscape maintenance. That cemetery indicated that 9.25 gallons – of the pesticide Sunbugger (0.5% diazinon) was used for landscape maintenance from about mid-1997 through about mid-1999. Assuming the density of the diazinon product was the same as that of water (8.34 pounds per gallon), this represents use of less than one pound of diazinon active ingredient per year. The cemeteries reported that all structural pest control was done under outside contract and no estimates of diazinon use were available. The cemeteries had little or no knowledge of IPM and did not have IPM plans.

Kennels – Only one kennel is located in the Chollas Creek watershed and it reported no use of diazinon.

CalTrans – CalTrans is responsible for the major freeways that run through the watershed. Roadways make up about 4% of the land in the watershed. However, CalTrans reports that diazinon is not used on its facilities. CalTrans reported that it has an IPM plan.

Nurseries – There are four nurseries in the Chollas Creek watershed. Three of these nurseries reported using no diazinon onsite. One nursery reported onsite use of about one gallon per year of a pesticide product containing diazinon. Assuming the density of the diazinon product was the same as that of water (8.34 pounds per gallon) and assuming the diazinon product contained 31% diazinon active ingredient (see Table 5, agriculture use category), this represents use of less than three pounds of diazinon active ingredient.

Nurseries are the only potential diazinon users in the Chollas Creek watershed included in the agriculture use category. Based on the results of this survey summarized above, reported agricultural diazinon use in the watershed was estimated to be negligible.

Reported diazinon use for landscape maintenance and structural pest control was estimated assuming that all such use in San Diego County occurred in urban land use settings. Since the Chollas Creek watershed contains approximately 5% of the total urban land use area in San Diego County, reported diazinon use for landscape maintenance and structural pest control in the watershed was estimated to be 5% of the total reported diazinon use in those categories in San Diego County. For purposes of this

TMDL, urban land uses were defined to consist of residential, commercial, and industrial uses. Roadways and open space were not considered urban land uses because diazinon is generally not used in these areas. As Table 6 indicates, structural pest control was estimated to be the predominant reported use of diazinon in the Chollas Creek watershed in 1997.

Table 6
Estimated Reported Diazinon Use in the Chollas Creek Watershed (1997)

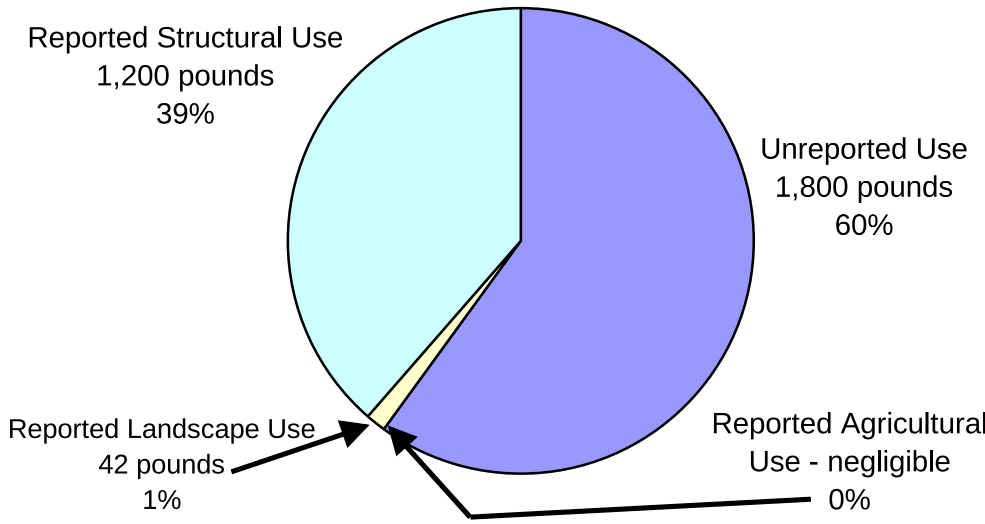
Use Category	Diazinon Active Ingredient (pounds*)	Diazinon Product (pounds*)
Agricultural	Negligible	Negligible
Landscape Maintenance	42	460
Structural Pest Control	1,200	4,800
Total (*rounded to two significant figures)	**1,200**	**5,300**

Unreported Use of Diazinon
Unreported uses include home, garden, industrial, and institutional uses of over-the-counter diazinon products. The amount of unreported diazinon use in residential, commercial, industrial, and institutional settings is not well documented. According to the DPR 1997 Summary of Pesticide Use Report Data (DPR 1997a), about two-thirds of pesticide active ingredient sold in a given year is used for unreported uses. For diazinon in urban areas, such as the Chollas Creek watershed, unreported uses account for approximately 60% of total use of diazinon active ingredient (Cooper 1996). Therefore, assuming that diazinon is discharged from various use categories to Chollas Creek in proportion to the amounts used in those categories, it appears that more diazinon is discharged to Chollas Creek from unreported uses than from reported uses.

The 1997 unreported use of diazinon active ingredient in the Chollas Creek watershed was estimated to be approximately 1,800 pounds. This estimate was calculated based on the assumption that 60% of the total use was unreported use and the estimate (from Table 6) of 1,200 pounds of reported use in the watershed in 1997. Figure 1 depicts the estimated reported uses and unreported use of diazinon in the Chollas Creek watershed.

The most common target pests for diazinon used in residential areas in the San Francisco Bay area are ants, fleas, grubs, and spiders (Cooper 1996, Scanlin and Cooper 1997 as cited in Katznelson and Mumley, 1997). Uses of diazinon are likely to be similar in the San Francisco Bay area and San Diego area. Although, some diazinon is used indoors, the amount used indoors appears to be a small fraction of the total amount of diazinon used.

Figure 1. Estimated Reported vs. Estimated Unreported Diazinon Use in the Chollas Creek Watershed



NPDES Permits

Another way to identify sources of diazinon is by identifying NPDES permits for discharges to Chollas Creek. Each discharge regulated by an NPDES permit can be considered a potential source of diazinon. There are several NPDES permits that regulate discharges that enter Chollas Creek directly or indirectly. Four of these permits are “storm water” permits, i.e. permits for discharges of runoff.

The SDRWQCB has issued and oversees compliance with a municipal storm water NPDES permit for San Diego County. This permit regulates all discharges to and from the storm water conveyance systems of all the cities in San Diego County, as well as the County of San Diego, and the San Diego Unified Port District. Storm water conveyance systems are transmission routes through which pollutants enter surface waters. Storm water NPDES permits are intended to reduce or eliminate the discharge of pollutants to and from storm water conveyance systems. The agencies (permittees) named in the municipal storm water NPDES permits are responsible for everything that is discharged to and from their storm water conveyance systems. The permittees are responsible for isolating and controlling sources of pollutants within their jurisdictions, even if the permittees do not actually use the pollutants. The permittees regulated by this permit that have jurisdiction in the Chollas Creek watershed are the City of San Diego, the City of Lemon Grove, the City of La Mesa, and the San Diego Unified Port District. These permittees have responsibility for discharges to and from the municipal storm water conveyance system in the watershed.

The State Water Resources Control Board (SWRCB) has issued a statewide NPDES general permit for industrial site runoff discharges. The SDRWQCB oversees compliance with this permit in the San Diego region. The municipal storm water permittees also have responsibility for runoff from industrial sites within their jurisdiction. The number of sites in the Chollas Creek watershed to which this permit applies has not yet been determined. Industrial sites could be significant sources of diazinon discharges, compared to other areas of similar size. However, it seems unlikely that such sites are major sources of diazinon discharges to Chollas Creek, since land use in the watershed is predominantly residential (Table 1). SDRWQCB staff has not conducted a survey about diazinon use at industrial sites and does not know of any measurements of diazinon in industrial site storm water discharges.

The SWRCB has issued a statewide NPDES general permit for construction site runoff discharges. The SDRWQCB oversees compliance with this permit in the San Diego region. The municipal storm water permittees also have responsibility for runoff from construction sites within their jurisdiction. The number of sites (if any) in the Chollas Creek watershed to which this permit currently applies has not yet been determined. Construction sites would not seem to be likely sources of significant discharges of diazinon. However, SDRWQCB staff has not conducted a survey about diazinon use at construction sites and does not know of any measurements of diazinon in construction site storm water discharges.

The SWRCB has issued a statewide storm water NPDES permit to the California Department of Transportation (CalTrans). This permit regulates all runoff discharges from Caltrans rights-of-way, maintenance yards, and other sites and facilities. However, CalTrans reports that no diazinon is used on such areas. Therefore, such areas would not seem to be likely sources of significant discharges of diazinon to Chollas Creek.

The SWRCB has also issued a statewide NPDES general permit for utility vault discharges. The SDRWQCB oversees compliance with this permit in the San Diego region. Several utilities in the San Diego region are regulated under this permit. SDRWQCB staff has not conducted a survey about diazinon use in utility vaults and does not know of any measurements of diazinon in utility vault discharges.

The SDRWQCB has also issued two NPDES general permits for groundwater extraction waste discharges. None of the discharges currently covered by these permits enter Chollas Creek.

Recommendations and Plans for Further Source Analysis

Because of the limited amount of information concerning sources of diazinon in the watershed, additional source analysis activities will be required in the implementation section of this TMDL. Some additional source analysis activities are currently ongoing or planned.

SDRWQCB staff understands that the Department of Pesticide Regulation (DPR) is planning to conduct some urban source analysis monitoring programs in the next few years. These DPR monitoring programs will be designed to better identify the products and uses which cause the highest diazinon concentrations in urban runoff. The results of these DPR urban monitoring programs are intended to be applicable statewide, regardless of where the monitoring is actually conducted.

The monitoring program for the municipal storm water NPDES permit for San Diego County has been modified to address some source analysis questions. A pesticide use survey will be conducted to characterize the use of diazinon by residential and commercial applicators in San Diego County. Additional monitoring for diazinon in Chollas Creek has been conducted.

Further investigation is needed to determine whether runoff from industrial sites, runoff from construction sites, and utility vault discharges may be significant sources of diazinon discharges to Chollas Creek. Such investigation may include surveys of diazinon use at industrial and construction sites and in utility vaults and monitoring of industrial and construction site runoff and utility vault discharges.

Improvements in the source analysis are expected to assist in the development of the implementation plan for this TMDL. The source analysis and implementation plan may be revised as new information becomes available.

Loading Capacity and Allocations

Loading Capacity Analysis

The loading capacity is the critical quantitative link between the applicable water quality standards and the TMDL. The applicable water quality standards are the Basin Plan narrative objectives for toxicity and pesticides and the two beneficial uses of Chollas Creek that could be adversely affected by toxicity and pesticides, i.e., warm freshwater habitat and wildlife habitat. The Basin Plan does not contain numeric objectives for toxicity or pesticides. Although the Basin Plan narrative objective for pesticides applies to diazinon, the Basin Plan does not contain an objective for diazinon, *per se*. This TMDL is based on a numeric target for diazinon based on the Water Quality Criterion for protection of freshwater aquatic organisms from diazinon developed by the Department of Fish and Game (Siepmann and Finlayson 2000). Achieving the numeric target for diazinon is expected to result in attainment of the narrative objectives for toxicity and pesticides and protection (from diazinon) of the warm freshwater habitat and wildlife habitat beneficial uses of Chollas Creek.

The mass-based loading capacity for Chollas Creek would be the maximum diazinon mass emission rate that could occur without causing non-attainment of the narrative objectives for toxicity and pesticides. The loading capacity expressed as a mass emission rate would vary with the flow rate in Chollas Creek. The lower the flow rate in the creek, the lower the diazinon mass emission rate would have to be to attain the narrative objective for toxicity. The effects of storm events are difficult to predict in a watershed like that of Chollas Creek. Flow rates in Chollas Creek are highly variable. The highest flow rates are associated with storm events, but different storm events cause different amounts of runoff and different amounts of diazinon in the runoff. The amount of runoff and the amount of diazinon in runoff depends on many factors, including the intensity, duration, and frequency of storms. During dry weather, some nuisance water runoff (e.g., from landscape irrigation), which may contain diazinon, enters the creek. During dry weather, there are often extended periods of no surface flows in the creek, although pools of standing water may be present. The variation in the flow rate in the creek, in the amount of runoff, and in the amount of diazinon in runoff makes it very difficult to estimate the maximum diazinon mass emission rate that could occur without causing non-attainment of the narrative objectives for toxicity and pesticides. However, the concentration of diazinon that would result in non-attainment of the narrative objectives for toxicity and pesticides is expected to be relatively constant. Therefore, this TMDL is based on concentration, rather than on mass emission rates.

Allocations

The mass-based loading capacity (i.e., maximum allowable mass emission rate, e.g., in pounds per day) for Chollas Creek would be the sum of "wasteload allocations" for point source discharges, plus "load allocations" for nonpoint source discharges, plus a margin of safety. Since the allocations in this TMDL are based on concentration (i.e., maximum allowable concentration, e.g., in µg/l) rather than mass emission rates, the allocations to each category are not additive. However, the allocations for each of these three categories are discussed below. The guiding principle for making allocations was to achieve the target concentrations in the creek by achieving the target concentrations in discharges into the creek. If discharges into the creek do not exceed the target concentrations, water in the creek should not exceed the target concentrations.

Wasteload Allocations

Wasteload allocations are assigned to point source discharges. Point source discharges to surface waters are regulated by NPDES permits. As discussed above, there are currently several NPDES permits that regulate discharges that enter Chollas Creek directly or indirectly. Wasteload allocations equal to the numeric targets are assigned to point source discharges (Table 7).

As previously discussed in the Source Analysis section, the discharge of runoff regulated under the municipal storm water permit is believed to be the primary source (or pathway) of diazinon entering Chollas Creek. Discharges regulated under the other NPDES permits are not believed to be major sources of diazinon entering Chollas Creek. However, it is possible that other point source discharges may contain some diazinon. To account for this possibility, the same wasteload allocations are assigned to all point source discharges.

Load Allocations

Load allocations are assigned to nonpoint sources. Since all runoff and other discharges which enter Chollas Creek directly or indirectly are regulated by one of the NPDES permits discussed above, there are no true nonpoint source discharges of diazinon to the creek. However, in order to be consistent, and in case assertions are made that discharges from some sources of diazinon are not regulated by an NPDES permit, this TMDL assigns load allocations to nonpoint sources as a group. The rationale for the load allocations for nonpoint sources is the same as that for the waste load allocations for point sources, i.e.; the load allocations are the same as the numeric targets.

Table 7
Numeric Targets, Waste Load Allocations, and Load Allocations for Diazinon in Chollas Creek

Type	Numeric Targets	Waste Load Allocations for Point Sources	Load Allocations for Nonpoint Sources
Acute	0.08 µg/l	0.08 µg/l	0.08 µg/l
Chronic	0.05 µg/l	0.05 µg/l	0.05 µg/l

Margin of Safety, Seasonal Variations, and Critical Conditions

Clean Water Act Section 303(d) and the regulations at 40 CFR 130.7 require that:

> "TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standards with seasonal variations and a margin of safety that takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality." (Emphasis added.)

Margin of Safety

The margin of safety can either be incorporated implicitly through conservative analytical approaches and assumptions used to develop the TMDL or added explicitly as a separate component of the TMDL.

The margin of safety for this TMDL is implicit. The goal of this TMDL is to reduce diazinon concentrations in Chollas Creek to meet the water quality objectives for toxicity and pesticides in Chollas Creek. The toxicity in Chollas Creek is caused by the insecticide diazinon, so the TMDL numeric targets and allocations are for diazinon. The numeric targets and allocations are based on the water quality criterion developed by the California Department of Fish and Game for protection of aquatic organisms from the insecticide diazinon. Attainment of these targets and allocations is expected to result in attainment of the narrative objectives for toxicity and pesticides, and, hence, protect (from diazinon) the warm freshwater habitat and wildlife habitat beneficial uses of Chollas Creek. A margin of safety was built into the water quality criterion for diazinon developed by the Department of Fish and Game (Siepmann and Finlayson 2000).

There is some uncertainty in the source analysis because the relationship between the amount of diazinon used or applied in the watershed and the amount of diazinon discharged to the creek is not known. However, since this TMDL is based on concentration, rather than on mass emission rates, this uncertainty is not critical.

Seasonal Variation and Critical Conditions

Evaluation of seasonal variations and critical conditions would appear to be most pertinent to TMDLs that establish numeric targets expressed in terms of mass emission rates (e.g., pounds per day). In this TMDL, however, the proposed numeric target is expressed in terms of the concentration (micrograms per liter) of diazinon in Chollas Creek water. The numeric targets are the same as the DFG water quality criterion for diazinon, which does not contain a seasonal or critical condition component. Consequently, regardless of the flow rate in the creek, if the numeric targets are achieved, the concentration of diazinon in the creek should not cause toxicity, and, hence, the Basin Plan narrative objective for toxicity should be met. Nevertheless, seasonal variation and critical condition considerations are discussed below.

Studies conducted in Alameda County, California found that diazinon was often detected in water and sediments of urban creeks throughout the year, not only during wet weather flows (Alameda County Flood Control and Water Conservation District 1997). These studies also suggest that diazinon in creek bed sediments is released to creek water (Alameda County Flood Control and Water Conservation District 1997). Consequently, creek bed sediments represent a reservoir from which diazinon can enter flowing water in a creek (or standing water in pools) even when no runoff enters the creek. These studies also suggest that diazinon toxicity is higher at higher temperatures (Alameda County Flood Control and Water Conservation District 1997).

There is not sufficient information available to characterize seasonal variations in the concentration of diazinon in Chollas Creek water or sediments. Neither is sufficient information available to characterize critical conditions in Chollas Creek. Because the Chollas Creek watershed is small and there are significant seasonal differences in rainfall in the watershed, there are significant seasonal differences in runoff from the watershed to the creek, and, hence, significant seasonal differences in flow rates in the creek. There is significant flow in Chollas Creek only during and immediately following rainfall events, which occur primarily from November through April. Other factors being equal, flow rates are highest during and immediately following major rainfall events. During the dry season, there are often extended periods of no surface flow, although some pools of standing water may be present in the creek bed.

It is possible that diazinon is illicitly discharged directly into Chollas Creek. However, in the absence of evidence of illicit discharges, runoff is believed to be the primary pathway by which diazinon enters both the water and the sediments of the creek. Runoff may be categorized as either storm water runoff or nuisance water runoff (e.g., from landscape irrigation). In any twelve-month period, by far the majority of runoff entering the creek is storm water runoff. Therefore, in the absence of information indicating otherwise, storm water runoff is believed to contain most of the mass of diazinon that enters the creek.

It is possible that one or both of two types of "first flush" phenomena influence diazinon concentrations in storm water runoff. One type of first flush phenomenon would result in higher diazinon concentrations in runoff from rainfall following extended periods without rainfall (e.g., early season and out-of-season rainfall). The other type of first flush phenomenon would result in higher diazinon concentrations in runoff from the first increment (e.g., 0.25 inches) of rainfall from a particular storm than in runoff from subsequent rainfall in excess of that first increment from the same storm. The Chollas Creek storm water flow monitoring for diazinon that has been conducted to date has not been sufficient to draw any conclusions about the presence or absence of first flush phenomena.

Although storm water runoff is likely to contain most of the mass of diazinon on an annual basis, nuisance water runoff (e.g., from landscape irrigation) may also contain diazinon. Although the annual volume of nuisance water runoff entering the creek is small in comparison to the annual volume of storm water runoff, nuisance water runoff enters the creek year-round. Consequently, at times of the year when there is little or no flow in the creek (i.e., during dry weather), nuisance water runoff may be of seasonal importance to diazinon concentrations and toxicity in low flows and standing water. The potential significance of diazinon in nuisance water runoff is underscored by the apparent greater toxicity of diazinon at higher temperatures (Alameda County Flood Control and Water Conservation District 1997) and the generally higher Chollas Creek water temperatures in the May through October dry season than in the November through April wet season. SDRWQCB staff does not know of any measurements of toxicity or diazinon concentrations in Chollas Creek dry weather flows or standing water.

Linkage Analysis
The linkage between the applicable water quality standards and this TMDL, which was explained previously in the Loading Capacity Analysis section, is repeated below.

The applicable water quality standards are the Basin Plan narrative objectives for toxicity and pesticides and the two beneficial uses of Chollas Creek that could be adversely affected by toxicity and pesticides (i.e., warm freshwater habitat and wildlife habitat.) The Basin Plan does not contain numeric objectives for toxicity or pesticides. Although the Basin Plan narrative objective for pesticides applies to diazinon, the Basin Plan does not contain an objective for diazinon, *per se*. This TMDL is based on a numeric target for diazinon based on the Water Quality Criterion for protection of freshwater aquatic organisms from diazinon developed by the Department of Fish and Game. Achieving the numeric target for diazinon is expected to result in attainment of the narrative objectives for toxicity and pesticides and protection (from diazinon) of the warm freshwater habitat and wildlife habitat beneficial uses of Chollas Creek.

Public Participation

40 CFR 130.7 requires that TMDLs be subject to public review. To date, three public workshops have been conducted on this TMDL. The first was on March 17, 1999, before diazinon was identified as the cause of toxicity in Chollas Creek water. The second was held on August 3, 1999. The third was held on December 17, 1999. A fourth is planned for May 17, 2000.

Information about development of this TMDL was and will continue to be made available to the public on the SDRWQCB website, <www.swrcb.ca.gov/~rwqcb9/>.

Additional opportunities for public participation will be provided during the USEPA TMDL promulgation process and during the SDRWQCB / SWRCB Basin Plan amendment process.

Implementation and Monitoring

A preliminary implementation and monitoring plan is outlined below. A more definitive plan will be developed at a later date.

Implementation is likely to involve one or the other or some combination of two basic approaches. The first approach would involve legal restrictions on the availability and use of diazinon and/or economic disincentives to diazinon use. The second approach would involve education and outreach with the aim of reducing diazinon use, changing the manner in which diazinon is used, and preventing improper disposal of diazinon. In order for either approach (or any combination thereof) to be effective, similar measures are also likely to be necessary for other pesticides (e.g., chlorpyrifos). In the absence of such measures, reductions in diazinon use may be offset by increased use of other pesticides, with the result of continued toxicity in aquatic systems.

The first approach may be warranted if monitoring indicates that diazinon-induced toxicity is widespread nationwide, statewide, or in the San Diego region. Under this approach, the SDRWQCB (on its own or in conjunction with other regional water quality control boards, the SWRCB, and/or other entities) would pursue one or more of the following through appropriate channels:

(a) Restrictions on or prohibition of the sale and use of diazinon;
(b) Imposition of substantial surcharges on the purchase price of diazinon; and/or
(c) Imposition of substantial fees on users of diazinon.

Under the second approach, the SDRWQCB would direct the NPDES permittees that discharge directly or indirectly to Chollas Creek to take actions to reduce the amount of diazinon entering the creek and to report on the effectiveness of such actions. Since the municipal storm water permittees have broad responsibility and authority within their respective areas of jurisdiction, and since CalTrans rights-of-way and facilities do not appear to be significant sources of diazinon discharges to Chollas Creek, the implementation and monitoring efforts would focus on the municipal storm water permittees with jurisdiction in the Chollas Creek watershed.

Actions that municipal storm water permittees could be directed to take include, but are not limited to, the following:

1. Expedite development and implementation of Integrated Pest Management plans by and for each permittee. Ensure that the IPM plan covers all pest control activities conducted by and for each permittee, including those conducted by commercial pesticide application businesses. Conduct regular audits of implementation of and adherence to the IPM plan.

2. Identify industrial, commercial, and institutional sites and facilities in the Chollas Creek watershed that are known or likely to use diazinon. Require that such users develop and implement Integrated Pest Management Plans. Ensure that IPM plans cover all pest control activities conducted by and for such users, including those conducted by commercial pesticide application businesses. Conduct regular audits of implementation of and adherence to IPM plans.
3. Work with the Department of Pesticide Regulation and the County Department of Agriculture – Weights & Measures to reduce discharges of diazinon resulting from diazinon use by commercial pesticide application businesses (including landscape maintenance businesses). Specific steps could include the following:
    a. Identify the locations of all commercial pesticide application businesses in and near the Chollas Creek watershed.
    b. Explain the water quality effects of diazinon to operators of such businesses.
    c. Provide such businesses with information on Best Management Practices (BMPs) to reduce diazinon in runoff and request that such businesses implement such BMPs when diazinon is used.
    d. Provide such businesses with information on alternative pest management measures that would reduce diazinon use by substitution of less persistent, less toxic substances and request that such businesses implement such measures.
    e. Request that such businesses not advertise or otherwise promote the sale or use of diazinon.
    f. Inspect such businesses located within the Chollas Creek watershed to ensure that onsite and offsite activities do not contribute diazinon to runoff.
    g. Inspect and evaluate pesticide disposal practices and locations used by such businesses.
4. Work with the Department of Pesticide Regulation and the County Department of Agriculture – Weights & Measures to reduce discharges of diazinon resulting from use of diazinon-containing products sold over-the-counter. Specific steps could include the following:
    a. Identify the locations of all businesses in and near the Chollas Creek watershed where diazinon is sold over-the-counter.
    b. Explain the water quality effects of diazinon to appropriate personnel of such businesses.
    c. Provide such businesses with information on Best Management Practices (BMPs) to reduce diazinon in runoff and request that such information be displayed with pesticides for sale and made readily available to customers.
    d. Provide such businesses with information on alternative pest management measures that would reduce diazinon use by substitution of less persistent, less toxic substances and request that such information be displayed with pesticides for sale and made

readily available to customers. Also request that alternative "environmentally friendly" substitutes be sold instead of (or at least in addition to) diazinon.

   e. Request that such businesses not advertise or otherwise promote the sale or use of diazinon.
   f. Inspect such businesses located within the Chollas Creek watershed to ensure that onsite and offsite activities do not contribute diazinon to runoff.
   g. Inspect and evaluate pesticide disposal practices and locations used by such businesses.

5. Work with the Department of Pesticide Regulation to require revision of label instructions on diazinon containers to incorporate (a) Best Management Practices (BMPs) to reduce diazinon in runoff and (b) directions for proper disposal.
6. Work with water supply organizations to encourage landscaping with species of plants that require little or no irrigation or use of pesticides.
7. Provide information and materials to schools, teachers, and students about water quality effects of diazinon, how to reduce diazinon in runoff, and how to properly dispose of diazinon.
8. Provide information to the public using various media (e.g., billing inserts, television and radio, newspapers and periodicals, brochures, the Internet, etc.) about water quality effects of diazinon, how to reduce diazinon in runoff, and how to properly dispose of diazinon.
9. Develop a "Master Gardener Program" which encourages integrated pest management and voluntary "point of sale" alternatives to toxic pesticide products.

In conjunction with both implementation approaches, the municipal storm water permittees would be directed to monitor the creek for diazinon and toxicity to determine if the TMDL numeric targets for diazinon and the Basin Plan narrative objectives for toxicity and pesticides are being met. Such monitoring could include monitoring by citizen and school groups for sources of toxicity (e.g., utilizing a simplified acute toxicity testing protocol with *Ceriodaphnia dubia*)(Katznelson, R., 1997). Involvement of citizen and school groups could result in greater public awareness of the water quality effects of diazinon, as well as providing additional water quality information.

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