May 1, 2014

Pamela Creedon
Central Valley Regional Water Quality Control Board
11020 Sun Center Drive, #200
Rancho Cordova, CA 95670-6114

Dear Ms. Creedon,

The East San Joaquin Water Quality Coalition (ESJWQC) and Westside San Joaquin River Watershed Coalition (Westside Coalition) are submitting the 2014 Annual Monitoring Report (AMR) for the San Joaquin River Chlorpyrifos and Diazinon TMDL Compliance Monitoring for review by the Central Valley Regional Water Quality Control Board (CVRWQCB).

The attached documents report on the monitoring program for the period of October 1, 2012 through September 30, 2013 and assesses compliance with the monitoring objectives as described in the Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Diazinon and Chlorpyrifos Runoff into the Lower San Joaquin River (finalized October 2005).

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for knowingly submitting false information, including the possibility of fine and imprisonment for violations."

This letter will be mailed to the CVRWQCB with an original signature.

Submitted respectfully,

Parry Klassen
Executive Director
East San Joaquin Water Quality Coalition

Joseph C. McGahan
Westside San Joaquin River Watershed Coalition

San Joaquin River Chlorpyrifos and Diazinon 2013 Water Year Annual Monitoring Report

For Compliance with the Central Valley Regional Water Quality Control Board Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Diazinon and Chlorpyrifos Runoff into the Lower San Joaquin River (October 2005)

Reporting period: October 1, 2012 – September 30, 2013

Report Submitted: May 1, 2014

Prepared by the East San Joaquin Water Quality Coalition and the Westside San Joaquin River Watershed Coalition

TABLE OF CONTENTS

Executive Summary 1
Introduction 4
Monitoring Objectives and Design 5
Monitoring Objectives 5
Monitoring Design 8
Constituents Monitored 12
Sample Site Descriptions 13
Land Use Analysis of Subareas 17
Rainfall Records 18
Sampling and Analytical Methods 21
Monitoring Results 23
Sample Details 23
Precision, Accuracy and Completeness 25
Completeness 25
Field and Transport Completeness 25
Analytical Completeness 26
Batch Completeness 26
Hold Time Compliance 27
Summary of Precision and Accuracy 27
Corrective Actions 29
Comparison with TMDL Objectives 30
Objective 1: Determine compliance with established water quality objectives and the loading capacity applicable to diazinon and chlorpyrifos in the San Joaquin River 30
Water Quality Objectives 30
Loading Capacity 31
Objective 2: Determine compliance with established load allocations for diazinon and chlorpyrifos. 32
ESJWQC Load Allocation Compliance 33
Westside Coalition Load Allocation Compliance 36
Objective 3: Determine degree of implementation of management practices and strategies to reduce off-site movement of diazinon and chlorpyrifos 40
ESJWQC Implementation of Management Practices to Reduce Off Site Movement of Diazinon and Chlorpyrifos 41
Westside Coalition Implementation of Management Practices to Reduce Off Site Movement of Diazinon and Chlorpyrifos 46
Objective 4: Determine degree of effectiveness of management practices and strategies to reduce off-site movement of diazinon and chlorpyrifos 47
ESJWQC Effectiveness of Management Practices to Reduce Off Site Movement of Diazinon and Chlorpyrifos 47
Westside Coalition Effectiveness of Management Practices to Reduce Off Site Movement of Diazinon and Chlorpyrifos 48
Objective 5: Determine whether alternatives to diazinon and chlorpyrifos are causing surface water quality impacts 49
Objective 6: Determine whether the discharge causes or contributes to toxicity impairment due to additive or synergistic effects of multiple pollutants. 62
Westside Coalition Evaluation of Toxicity Impairment Due to Additive or Synergistic Effects of Multiple Pollutants 63
Objective 7: Demonstrate that management practices are achieving the lowest pesticide levels technically and economically achievable 65
Conclusions and Recommendations 67
References 69

LIST OF TABLES

Table 1. WQOs for chlorpyrifos and diazinon. 5
Table 2. Monitoring Objectives and actions by ESJWQC and Westside Coalition for the control of diazinon and chlorpyrifos runoff into the lower San Joaquin River. 7
Table 3. The ESJWQC and Westside Coalition MRP Order/MRPP, QAPP, AMRs/SAMRs, Management Plans, and MPURs submission dates. 8
Table 4. San Joaquin River chlorpyrifos and diazinon compliance sites designated in the Basin Plan Amendment; subareas that drain to those sites; and a crosswalk of the station names as used in the appendices and electronic files of this report (Appendices Station Name and Code) and in California Environmental Data Exchange Network (CEDEN; Station Name and Code)..... 14
Table 5. The ESJWQC and Westside Coalition upstream tributary monitoring during 2013 WY and most immediate downstream SJR monitoring sites. 15
Table 6. Estimated land use acreage upstream of the San Joaquin River compliance points. 17
Table 7. Top ten commodities (based on acreage) upstream of each San Joaquin River sampling site for 2013 WY. 18
Table 8. Sampling procedures, containers, sample volumes, preservation and storage techniques, and holding times. 22
Table 9. Field parameters and instruments used to collect measurements. 22
Table 10. Site specific discharge methods. 22
Table 11. Field and laboratory analytical methods. 22
Table 12. Dates of monitoring at San Joaquin River and upstream tributary sites during the 2013 WY. 24
Table 13. The ESJWQC and Westside Coalition sample counts, field QC counts, and percentages. 26
Table 14. The ESJWQC and Westside Coalition summary of holding time evaluations for environmental, FB, FD, and MS samples. 27
Table 15. The ESJWQC and Westside Coalition summary of QA/QC evaluations. 28
Table 16. Exceedances of the WQO for chlorpyrifos at San Joaquin River sites during the 2013 WY. 30
Table 17. Chlorpyrifos and diazinon loading capacity calculations for San Joaquin River sites out of compliance during the 2013 WY..... 31
Table 18. Tally of chlorpyrifos and diazinon TMDL load capacity compliance per site (December 2010 through September 2013). 32
Table 19. The ESJWQC tributary monitoring schedule for chlorpyrifos (C) and diazinon (D) during the 2013 WY..... 34
Table 20. Chlorpyrifos and diazinon load allocation calculations for Tributary sites in the ESJWQC out of compliance during the 2013 WY..... 35
Table 21. Chlorpyrifos applications made four weeks prior in subwatersheds with chlorpyrifos exceedances. 35
Table 22. Tally of ESJWQC chlorpyrifos and diazinon TMDL load allocation compliance for each subarea since inception of San Joaquin River monitoring (January 2010 through September 2013). 36
Table 23. Westside Coalition tributary monitoring schedule during the 2013 WY. 37
Table 24. Chlorpyrifos and diazinon load allocation calculations for tributary sites in the Westside Coalition out of compliance during the 2013 WY. 38
Table 25. Tally of Westside Coalition chlorpyrifos and diazinon TMDL load allocation compliance per each of the subareas. 39
Table 26. Chlorpyrifos and diazinon applications made four weeks prior in subwatersheds with exceedances in the Westside Coalition region..... 40
Table 27. Current and newly implemented management practices designed to reduce offsite movement of chlorpyrifos and diazinon in the ESJWQC first, second, third, and fourth priority subwatersheds listed by TMDL subarea. 45
Table 28. Management practice inventory data for subwatersheds in the Westside Coalition region. 47
Table 29. Count of exceedances and samples collected for chlorpyrifos and diazinon in the ESJWQC first, second, third, and fourth priority site subwatersheds. 48
Table 30. Commodities with the most pounds of chlorpyrifos and diazinon use in the ESJWQC region from 2004 through 2013. 51
Table 31. High priority pests of the commodities that use the most diazinon and/or chlorpyrifos in the ESJWQC region, with alternative pesticides recommended for those pests. 51
Table 32. Trends in the use of chlorpyrifos, diazinon, and alternative pesticides applied per year to crops in the ESJWQC region since 2007. 54
Table 33. The ESJWQC tributary monitoring schedule for potential alternatives to chlorpyrifos and diazinon during the 2013 WY..... 57
Table 34. Water column detections of potential alternative pesticides in ESJWQC tributaries during the 2013 WY..... 58
Table 35. The ESJWQC tributary water column and sediment toxicity exceedance summary for the 2013 WY. 59
Table 36. The ESJWQC tributary chlorpyrifos and pyrethroid results for toxic sediment samples collected during the 2013 WY.59
Table 37. Insecticide applications within the Westside Coalition in order of highest application area. 60

Table 38. Westside Coalition tributary water column toxicity exceedance summary for 2013 WY. 63
Table 39. The Westside Coalition tributary sediment toxicity exceedance summary for the 2013 WY. 65

LIST OF FIGURES

Figure 1. Formula used to calculate chlorpyrifos and diazinon loading capacity in SJR and load allocation for waterways entering the River..... 5
Figure 2. Pounds of diazinon applied in the lower San Joaquin River watershed from 2004 through September 2013. 10
Figure 3. Pounds of chlorpyrifos applied in the lower San Joaquin River watershed from 2004 through September 2013..... 10
Figure 4. Chlorpyrifos and diazinon San Joaquin River TMDL Decision Tree for compliance monitoring and actions resulting from non-compliance of the San Joaquin River load capacity. 11
Figure 5. San Joaquin River tributary subareas, Chlorpyrifos and Diazinon TMDL compliance sites (circles), and tributary sites monitored by ESJWQC (squares) and Westside Coalition (triangles) during the 2013 WY..... 16
Figure 6. Precipitation history from October 1, 2012 through March 31, 2013. 19
Figure 7. Precipitation history from April 1 through September 30, 2013..... 20
Figure 8. Acreage with one or more implemented management practice per each category in the ESJWQC first, second, third, and fourth priority subwatersheds. 44
Figure 9. Count of chlorpyrifos and diazinon detections from 2006 through 2013 in the Westside Coalition tributaries. 49
Figure 10. Pounds of diazinon and chlorpyrifos applied in the ESJWQC region from 2004 through 2012 calendar years. 50

LIST OF APPENDICES

Appendix I	Chain of Custody Forms
Appendix II	Monitoring Results
Appendix III	Field and Laboratory QA Results
Appendix IV	Concentration Based Load Calculations
Appendix V	Field Sheets
Appendix VI	Monitoring Photos

LIST OF ACRONYMS

AI	Active Ingredient
AMR	Annual Monitoring Report
BPA	Basin Plan Amendment
CalPIP	California Pesticide Information Portal
CDEC	California Data Exchange Center
CEDEN	California Environmental Data Exchange Network
CIMIS	California Irrigation Management Information System
COC	Chain of Custody
CV RDC	Central Valley Regional Data Center
DO	Dissolved Oxygen
DWR	(California) Department of Water Resources
EPA	Environmental Protection Agency
ESJWQC	East San Joaquin Water Quality Coalition
FB	Field Blank
FD	Field Duplicate
ILRP	Irrigated Lands Regulatory Program
LCS	Laboratory Control Spike
LCSD	Laboratory Control Spike Duplicate
MDL	Minimum Detection Limit
MLJ-LLC	Michael L. Johnson, LLC
MPM	Management Plan Monitoring
MPUR	Management Plan Update Report
MRP	Monitoring and Reporting Program Order No R5-2008-0831
MRPP	Monitoring and Reporting Program Plan
MS	Matrix Spike
MSD	Matrix Spike Duplicate
NA	Not Applicable
ND	Not Detected
NONPJ	Non-project
NS	Not Sampled
OP	Organophosphate
pH	Power of Hydrogen

PR	Percent Recovery
PUR	Pesticide Use Report
PFTE	Polytetrafluoroethylene
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RL	Reporting Limit
RPD	Relative Percent Difference
S	Sum
SAMR	Semi-Annual Monitoring Report
SC	Specific Conductance
SJR	San Joaquin River
SM	Standard Methods for the Examination of Water and Wastewater
SWAMP	Surface Water Ambient Monitoring Program
TIE	Toxicity Identification Evaluation
TMDL	Total Maximum Daily Load
USDA	United States Department of Agriculture
USGS	United States Geological Survey
Westside Coalition	Westside San Joaquin River Watershed Coalition
Westside Coalition MRP	Westside San Joaquin River Watershed Coalition Monitoring and Reporting Program Order No R5-2008-0831
WQO	Water Quality Objective
WY	Water Year
YSI	Yellow Springs Instruments

LIST OF UNITS

cm	centimeter
cfs	cubic feet per second
°C	degrees Celsius
L	Liter
µg	microgram
µmhos	micromhos
µS	microsiemens
mg	milligram

LIST OF TERMS

ArcGIS – Geographic Information Systems mapping software
Basin Plan – Water Quality Control Plan for the Sacramento River and San Joaquin River Basins, Fourth Edition
Basin Plan Amendment – Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Diazinon and Chlorpyrifos Runoff into the Lower San Joaquin River (Final Staff Report October 2005)
Coalitions – East San Joaquin Water Quality Coalition and Westside San Joaquin River Watershed Coalition
Drainage – water that moves horizontally across the surface or vertically into the subsurface from land
ESJWQC region – The region within the Central Valley in which the East San Joaquin Water Quality Coalition is responsible for implementing the Irrigated Lands Regulatory Program (ILRP) on behalf of its members
Not detected – The concentration of a constituent within a sample is below the minimum detection limit
Regional Board – Central Valley Regional Water Quality Control Board
Waterbody – standing or flowing water of any size that may or may not move into a larger body of water, including lakes, reservoirs, ponds, rivers, streams, tributaries, creeks, sloughs, canals, laterals and drainage ditches
Water Year – the twelve month period from October through September, designated by the calendar year in which it ends and which includes nine of the twelve months
Watershed – The land area that drains into a stream; the watershed for a major river may encompass a number of smaller watersheds that ultimately combine at a common point. [Environmental Protection Agency (EPA) terms of environment: http://www.epa.gov/OCEPAterms/wterms.html)]
Westside Coalition region – The region within the Central Valley in which the Westside San Joaquin River Watershed Coalition is responsible for implementing the ILRP on behalf of its members

EXECUTIVE SUMMARY

The Lower San Joaquin River (SJR) is divided into seven subareas as described in the Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Diazinon and Chlorpyrifos Runoff into the Lower San Joaquin River (hereafter Basin Plan Amendment). The Central Valley Regional Water Quality Control Board (Regional Board) developed the Basin Plan Amendment (finalized in October 2005) to establish a Total Maximum Daily Load (TMDL) for the organophosphate (OP) pesticides chlorpyrifos and diazinon in the lower reaches of the SJR. As part of the Basin Plan Amendment, a surveillance and monitoring program is required to collect information necessary to assess compliance with seven monitoring objectives. The East San Joaquin Water Quality Coalition (ESJWQC) and Westside San Joaquin River Watershed Coalition (Westside Coalition) developed a monitoring strategy to comply with the chlorpyrifos and diazinon TMDL program Monitoring Objectives:

1. Determine compliance with established water quality objectives (WQOs) and the loading capacity applicable to diazinon and chlorpyrifos in the SJR.
2. Determine compliance with established load allocations for diazinon and chlorpyrifos.
3. Determine the degree of implementation of management practices to reduce off-site movement of diazinon and chlorpyrifos.
4. Determine the effectiveness of management practices and strategies to reduce off-site migration of diazinon and chlorpyrifos.
5. Determine whether alternatives to diazinon and chlorpyrifos are causing surface water quality impacts.
6. Determine whether the discharge causes or contributes to toxicity impairment due to additive or synergistic effects of multiple pollutants.
7. Demonstrate that management practices are achieving the lowest pesticide levels technically and economically achievable.

The monitoring design for the 2013 Water Year (WY) was similar to the monitoring design utilized during the 2012 WY which involved monitoring on the SJR to determine load compliance and monitoring in tributaries to determine load allocation. An additional modification to the monitoring program was required based on a letter received from the Regional Board on January 10, 2013 indicating the monitoring timing and frequency at the six SJR TMDL compliance points for chlorpyrifos and diazinon increased from five to six monitoring events, once during a storm event in January or February (winter storm season), and monthly from May through September.

The six compliance points (from upstream to downstream) are:

- San Joaquin River at Sack Dam,
- San Joaquin River at Highway 165 (Lander Ave) near Stevinson (USGS 11260815),
- San Joaquin River at Hills Ferry,
- San Joaquin River at Las Palmas Avenue near Patterson (USGS 11274570),
- San Joaquin River at the Maze Boulevard (Highway 132) Bridge (USGS 11290500), and
- San Joaquin River at the Airport Way Bridge near Vernalis (USGS 11303500).

This monitoring design also includes monthly monitoring at three of the six compliance points (San Joaquin River at Sack Dam, San Joaquin River at Highway 165 near Stevinson, and San Joaquin River at Las Palmas Avenue near Patterson), as well as tributary monitoring on a monthly basis based on each Coalitions' approved monitoring plan. The ESJWQC and Westside Coalitions assess monitoring results based on the monitoring objectives and report these results annually on May 1.

Water samples collected from the SJR were analyzed for chlorpyrifos and diazinon. Habitat information and field data, including dissolved oxygen (DO), pH, specific conductance (SC), and water temperature, were collected at each site during each monitoring event. Discharge was obtained from the Department of Water Resources (DWR) gauge readings posted on the California Data Exchange Center (CDEC) Website. The ESJWQC and Westside Coalition created a decision tree to guide the Coalition's actions when a non-compliant load is detected in the SJR.

During the 2013 WY, one exceedance of the Water Quality Objective (WQO) for chlorpyrifos occurred in the San Joaquin River at Las Palmas Avenue near Patterson on March 2013. However, the Coalitions remain in compliance with TMDL loading capacity, as the Basin Plan states that WQOs for chlorpyrifos and diazinon are not to be exceeded more than once in a three year period (p. III-6.01). There was one exceedance each of the chlorpyrifos (September 2013) and diazinon (February 2013) WQTLs in samples collected from ESJWQC tributaries (Tuolumne River and Merced subareas; respectively). An exceedance of the WQO for chlorpyrifos has not occurred in the Tuolumne River or the Northeast Bank subareas since July 2010; and there have been no exceedances of the WQO for diazinon in any tributary in the ESJWQC region since February 2008, and no detections since February 2009. In the Westside Coalition region, chlorpyrifos was detected in twelve water samples (over six different monitoring events) and diazinon was detected in ten samples (over two monitoring events). All these detections were measured in excess of the load criteria. Two sediment samples collected from an ESJWQC tributary had concentrations of chlorpyrifos that had the potential to cause toxicity. In all of the samples exhibiting toxicity within the Westside Coalition region, there was no indication of synergistic effects. Potential alternative pesticides to chlorpyrifos and/or diazinon were detected in the ESJWQC and Westside Coalition regions, but it is unknown if the pesticides were used as an alternative or as part of a rotation to manage specific pests. The management practices implemented by growers in both Coalition regions are achieving the lowest pesticide levels technically and economically feasible.

To address water quality impairments, the ESJWQC developed a management plan for waterways and prioritized both the waterways and constituents detected in those waterways. The Coalition focuses on constituents likely originating from agriculture including pesticides and suspended solids. The outreach and education strategy is designed to inform growers of impairments in their watershed and provide information on effective management practices. A key component of the ESJWQC's management strategy is to hold individual member meetings to discuss farm management practices and water quality impairments. The Coalition considers the significant decrease in exceedances of the WQO for chlorpyrifos since outreach began an important step in demonstrating the effectiveness of its management plan strategy. By demonstrating water quality improvements, the ESJWQC received approval on May 30, 2012 and October 15, 2013 to remove specific site/constituent pairs from active

management plans. To date, the Coalition has received approval to remove 38 management plans for constituents in 18 site subwatersheds. Of the 38 removed, two management plans were reinstated based on exceedances during the 2013 WY; therefore, a total of 36 constituents remain removed for 17 site subwatersheds in the ESJWQC region.

The Westside Coalition is also in the process of evaluating management practice implementation and effectiveness. To accomplish this, the Westside Coalition utilizes its two-pronged strategy guided by the tiered approach described in the Westside Coalition Management Plan. Because there is likely an overlap in effect from practices to address a specific constituent, the Westside Coalition identified a prioritized, tiered list of actions to be taken to address impairments of the most immediate concern (highest tier constituents), and, presumably, those actions will also benefit lower prioritized (tiered) constituents. These actions are then employed under two concurrent approaches (prongs) to improve water quality within the region. The General Approach identifies and employs common, constituent-specific strategies that can be applied throughout the region. Focused Watershed Management Plans, the second prong, identify and employ a subwatershed specific approach to implement management practices and improve water quality. Together, these strategies enable the Westside Coalition to adequately assess water quality and management practice implementation in its region. Management practices assessments are reported in the Westside Coalition Semi-Annual Monitoring Reports (SAMRs).

Both Coalitions monitor chlorpyrifos, diazinon, and several other constituents as a part of tributary monitoring within their respective regions. Results from ESJWQC and Westside Coalition tributary monitoring during the reporting period (October 2012 through September 2013) are discussed as they pertain to the TMDL Monitoring Objectives 1 through 7. Additional details can be found in the ESJWQC Annual Monitoring Report (AMR) submitted March 1, 2013, ESJWQC Annual Report submitted May 1, 2014, and the Westside Coalition SAMRs submitted June 15, 2013 (September 2012 through February 2013 data) and November 30, 2013 (March 2013 through August 2013 data) and to be submitted in the June 15, 2014 Semi-Annual Monitoring Report (SAMR) (September 2013 data).

INTRODUCTION

The lower San Joaquin River (SJR) is divided into seven subareas as described in the Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Diazinon and Chlorpyrifos Runoff into the Lower San Joaquin River (hereafter Basin Plan Amendment or BPA). The seven areas include agricultural drainages monitored under the Irrigated Lands Regulatory Program (ILRP) by the East San Joaquin Water Quality Coalition (ESJWQC) and Westside San Joaquin River Watershed Coalition (Westside Coalition). These two Coalitions were formed to ensure growers within those regions were in compliance with ILRP regulations.

The Central Valley Regional Water Quality Control Board (Regional Board) developed the Basin Plan Amendment (finalized in October 2005) to establish a Total Maximum Daily Load (TMDL) for the organophosphate (OP) pesticides chlorpyrifos and diazinon in the lower reaches of the SJR. The Basin Plan Amendment requires a surveillance and monitoring program to collect information necessary to assess compliance with seven monitoring objectives. Assessment of compliance with the Basin Plan Amendment is addressed at two levels: 1) water quality within the lower SJR at six compliance points (load capacity), and 2) water quality within the subareas that drain to the lower SJR (load allocations).

The ESJWQC and the Westside Coalition conducted monitoring during the 2013 Water Year (WY) (October 2012 through September 2013) to assess compliance with the lower SJR concentration based loads at the six compliance points identified in the Basin Plan Amendment. This report summarizes the water quality monitoring conducted at the compliance points during the reporting period and compares those results with the water quality objectives (WQOs) outlined in the Water Quality Control Plan for the Sacramento River and SJR Basins (Fourth Edition, hereafter referred to as the Basin Plan).

Each Coalition conducts a monitoring program under the ILRP designed to assess water quality within their region. In addition, both Coalitions developed management plans to address exceedances of the water quality objectives for chlorpyrifos and diazinon in specific subwatersheds. Results in this report are from an additional monitoring program conducted by the Coalitions to address the Basin Plan Amendment's regulation of discharges of OP pesticides. This annual report also includes data to demonstrate how the Coalitions are complying with load allocations for the subareas that drain to the SJR. Compliance is achieved through the monitoring and implementation strategies outlined the Coalition's respective monitoring and management plans.

MONITORING OBJECTIVES AND DESIGN

MONITORING OBJECTIVES

The ESJWQC and Westside Coalition developed a monitoring strategy to comply with the chlorpyrifos and diazinon TMDL program Monitoring Objectives. The Monitoring Objectives include:

1. Determine compliance with established water quality objectives (WQOs) and the loading capacity applicable to diazinon and chlorpyrifos in the SJR.
2. Determine compliance with established load allocations for diazinon and chlorpyrifos.
3. Determine the degree of implementation of management practices to reduce off-site movement of diazinon and chlorpyrifos.
4. Determine the effectiveness of management practices and strategies to reduce off-site migration of diazinon and chlorpyrifos.
5. Determine whether alternatives to diazinon and chlorpyrifos are causing surface water quality impacts.
6. Determine whether the discharge causes or contributes to toxicity impairment due to additive or synergistic effects of multiple pollutants.
7. Demonstrate that management practices are achieving the lowest pesticide levels technically and economically achievable.

The chlorpyrifos and diazinon WQOs (Basin Plan, Fourth Edition, Page III-6.01) are used to determine compliance with the concentration based loading capacity for the SJR and load allocations within the upstream tributaries (Table 1). As indicated in the Basin Plan, both the loading capacity of the SJR and load allocation of any tributary to the river shall not exceed one, as determined by the formula in Figure 1.

Table 1. WQOs for chlorpyrifos and diazinon.

Pesticide	Maximum Concentration and Average Period
Chlorpyrifos	0.025 µg/L ; 1-hour average (acute) 0.015 µg/L ; 4-day average (chronic) Not to be exceeded more than once in a three year period.
Diazinon	0.16 µg/L ; 1-hour average (acute) 0.10 µg/L ; 4-day average (chronic) Not to be exceeded more than once in a three year period.

Figure 1. Formula used to calculate chlorpyrifos and diazinon loading capacity in SJR and load allocation for waterways entering the River.

$$S = \frac{C_D}{WQO_D} + \frac{C_C}{WQO_C} \leq 1.0$$

C_D = diazinon concentration in µg/L
C_C = chlorpyrifos concentration in µg/L
WQO_D = diazinon water quality objective; 0.1 µg/L
WQO_C = chlorpyrifos water quality objective; 0.015 µg/L

The 4-day average (chronic) maximums listed in Table 1 are the WQOs for diazinon and chlorpyrifos. The loading capacity at any location/time is exceeded if the measured concentration of either constituent exceeds their respective WQOs in a sample collected from the SJR. The load allocation is exceeded if the measured concentration of either constituent exceeds the Water Quality Objective (WQO) in a sample collected from a tributary within one of the seven subareas. The chlorpyrifos and diazinon loading capacity or load allocation can also be exceeded if the combined concentrations of chlorpyrifos and diazinon cause the sum (S) (Figure 1) to be greater than one, even if both concentrations are below the respective WQOs.

To assess compliance with Objective 1 (loading capacity), the ESJWQC and Westside Coalition conducted monitoring at six designated compliance sites on the SJR during the 2013 WY. To assess compliance with Objectives 2 (load allocation) through 7, the Coalitions reviewed results from the SJR monitoring and outreach conducted within their respective Coalition regions as a part of the ILRP. Table 2 is an overview of the ESJWQC and Westside Coalition actions and associated reporting documents utilized to assess each of the seven Monitoring Objectives. The Comparison with TMDL Objectives section of this report details each Coalition's strategy to assess compliance with each of the objectives and the outcomes of their strategies during the reporting period. Table 3 lists all the ESJWQC and Westside Coalition submittal dates for each of their reporting elements listed in Table 2; each relevant document is listed below for each Coalition as reference.

Westside Coalition

- Westside Coalition Monitoring and Reporting Program Order No R5-2008-0831 (MRP)
- Westside Coalition Quality Assurance Project Plan (QAPP, approved January 7, 2014)
- Westside Coalition Semi-Annual Monitoring Reports (SAMR) with management plan status updates
- Westside Coalition Management Plan and Focused Watershed Plans

ESJWQC

- ESJWQC Monitoring and Reporting Program Plan (MRPP)
- ESJWQC Quality Assurance Project Plan (QAPP)
- ESJWQC Annual Monitoring Reports (AMR)
- ESJWQC Management Plan
- ESJWQC Management Plan Update Reports (MPUR)
- ESJWQC Annual Report

Table 2. Monitoring Objectives and actions by ESJWQC and Westside Coalition for the control of diazinon and chlorpyrifos runoff into the lower San Joaquin River.

Objective Number	Coalition Actions	Location of Additional Information[1]
1	• Monitor 6 compliance sites on the San Joaquin River. • Assess monitoring results to determine compliance with chlorpyrifos and diazinon WQO and loading capacity.	This report
2	• Conduct representative monitoring of the Coalition region according to Monitoring Strategy. • Assess monitoring results to determine compliance with chlorpyrifos and diazinon load allocations.	1,4,6,7,8,9
3-4	• Adhere to strategy put forth in the Management Plans. • Assess and review results of management plan strategy to determine the degree of implementation and the effectiveness of management practices implemented to reduce off-site movement of chlorpyrifos and diazinon.	4,6,7,9,11
5	• Conduct representative monitoring of Coalition region according to Monitoring Strategy. • Assess monitoring results to determine whether alternatives to diazinon and chlorpyrifos are causing surface water impairments.	1,4,6,7,8,11
6	• Conduct representative monitoring of Coalition region according to Monitoring Strategy. • Assess monitoring results to assess toxicity and determine if agricultural discharge contributes to toxicity impairment due to additive or synergistic effects of multiple pollutants.	1,4,6,7,8,11
7	• Assess the information collected to meet Objectives 3 and 4 to determine if management practices are achieving the lowest pesticides levels technically and economically achievable according to Management Plans.	4,6,7,9,11

[1] Number references for additional information refer to reports listed in Table 3

Table 3. The ESJWQC and Westside Coalition MRP Order/MRPP, QAPP, AMRs/SAMRs, Management Plans, and MPURs submission dates.

Document Name	Submission Date	Sampling Dates Addressed
(1) ESJWQC MRPP	8/25/2008	NA
(2) ESJWQC QAPP	8/25/2008 2/15/2013[1]	NA
(3) ESJWQC SAMR	6/30/2008 3/1/2009	October 2007 – September 2008
(4) ESJWQC Management Plan	9/30/2008	August 2004 – December 2007
(5) ESJWQC AMR	3/1/2010 3/1/2011 3/1/2012 3/1/2013	October 2008 – December 2012
(6) ESJWQC MPUR	4/1/2010 4/1/2011 4/1/2012 4/1/2013	October 2008 – December 2012
(7) ESJWQC Annual Report	5/1/2014	January-September 2013
(8) Westside Coalition MRP Order No.R5-2008-0831	9/15/2008	NA
(9) Westside Coalition Management Plan and Focused Management Plan	10/23/2008	March 2009 to Present
(10) Westside Coalition QAPP	1/07/2014	NA
(11) Westside Coalition SAMR	6/15/2009 11/30/2009 6/15/2010 11/30/2010 6/15/2011 11/30/2011 6/15/2012 11/30/2012 6/15/2013 11/30/2013	September 2008 – August 2013

[1] Most recent amendment
AMR – Annual Monitoring Report
ESJWQC – East San Joaquin Water Quality Coalition
MPUR – Management Plan Update Report
MRP - Westside Coalition Monitoring and Reporting Program Order No R5-2008-0831
MRPP – Monitoring and Reporting Program Plan
NA – Not Applicable. The document addresses and is applicable to the entire project, not a subset of sampling dates
QAPP – Quality Assurance Project Plan
SAMR – Semi-Annual Monitoring Report

MONITORING DESIGN

Monitoring is designed to characterize the concentrations of chlorpyrifos and diazinon in the SJR. The Regional Board determined that monitoring for the chlorpyrifos and diazinon TMDL in the six SJR compliance points should focus on periods of peak applications, and months when chlorpyrifos and diazinon have been detected above the WQTL in the SJR or its tributaries. Chlorpyrifos and diazinon use over time is shown in Figure 2 and Figure 3. The peak period of diazinon use has changed over time. In 2012, 75% of diazinon use occurred between April and June, compared to 2011 and before when the peak period for diazinon was between December and February. This trend was similar in 2013, though Pesticide Use Report (PUR) data are incomplete for 2013.

The monitoring design for the 2013 Water Year (WY) was similar to the monitoring design utilized during the 2012 WY with one exception. A modification to the monitoring program was required based on a letter received from the Regional Board on January 10, 2013 indicating the timing and frequency of monitoring at the six SJR TMDL compliance points needed to increase from five to six monitoring events, once during a storm event in January or February (winter storm season), and monthly from May through September. Hence, a monitoring event in September 2013 was added compared to the 2012 WY, due to exceedances of the WQTL for chlorpyrifos observed in tributaries in September during recent years.

During the 2013 WY, the ESJWQC monitored three of the six compliance points (San Joaquin River at Hills Ferry Road, San Joaquin River at the Maze Boulevard (Highway 132) Bridge, and San Joaquin River at the Airport Way Bridge near Vernalis). ESJWQC was done once in February and from May through September. The Westside Coalition monitored the other three compliance points (San Joaquin River at Sack Dam, San Joaquin River at Highway 165 near Stevinson, and San Joaquin River at Las Palmas Avenue near Patterson). Westside Coalition monitoring for chlorpyrifos and diazinon occurred monthly.

San Joaquin River TMDL monitoring, ESJWQC tributary monitoring, and Westside Coalition tributary monitoring are typically scheduled for the second Tuesday of the month and are adjusted for storm events as necessary. The Coalitions report chlorpyrifos and diazinon TMDL monitoring results from the previous WY annually on May 1. This report includes a complete analysis and discussion of all monitoring data collected from October 2012 through September 2013. If a non-compliant load is detected in the SJR, the Coalitions utilize the decision in Figure 4 to guide the Coalition's actions to address any water quality impairments in a timely and efficient manner.

Figure 2. Pounds of diazinon applied in the lower San Joaquin River watershed from 2004 through September 2013.

Years refer to calendar years. All PUR data are considered preliminary until received from California Pesticide Information Portal (CalPIP); CalPIP data are available through December 2011.

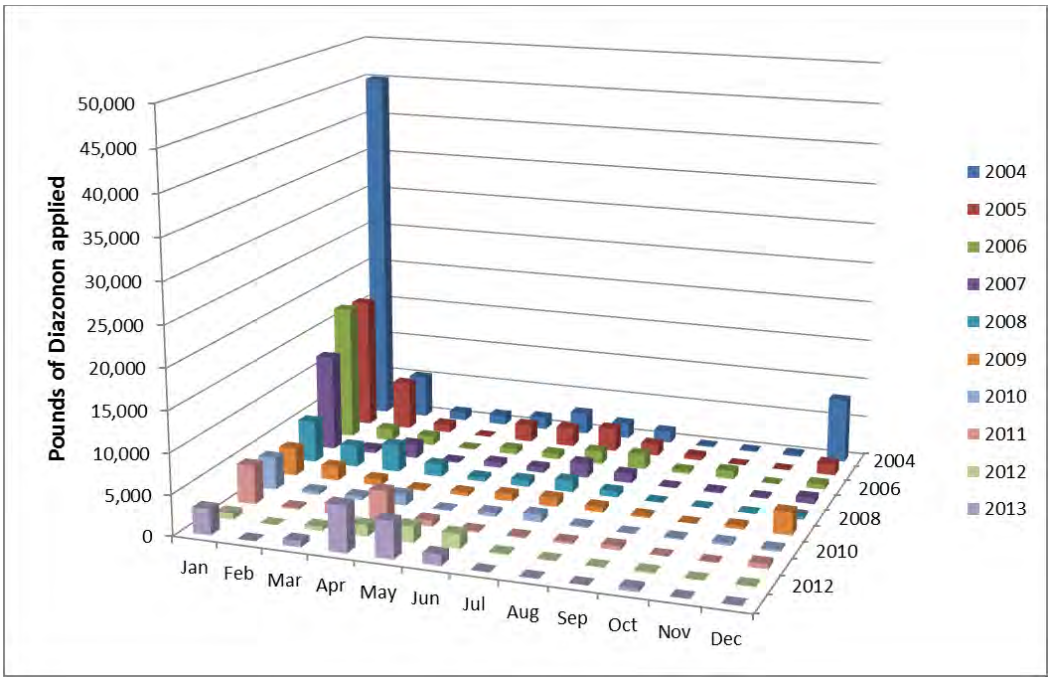


Figure 3. Pounds of chlorpyrifos applied in the lower San Joaquin River watershed from 2004 through September 2013.

Years refer to calendar years. All PUR data are considered preliminary until received from CalPIP; CalPIP data are available through December 2011.

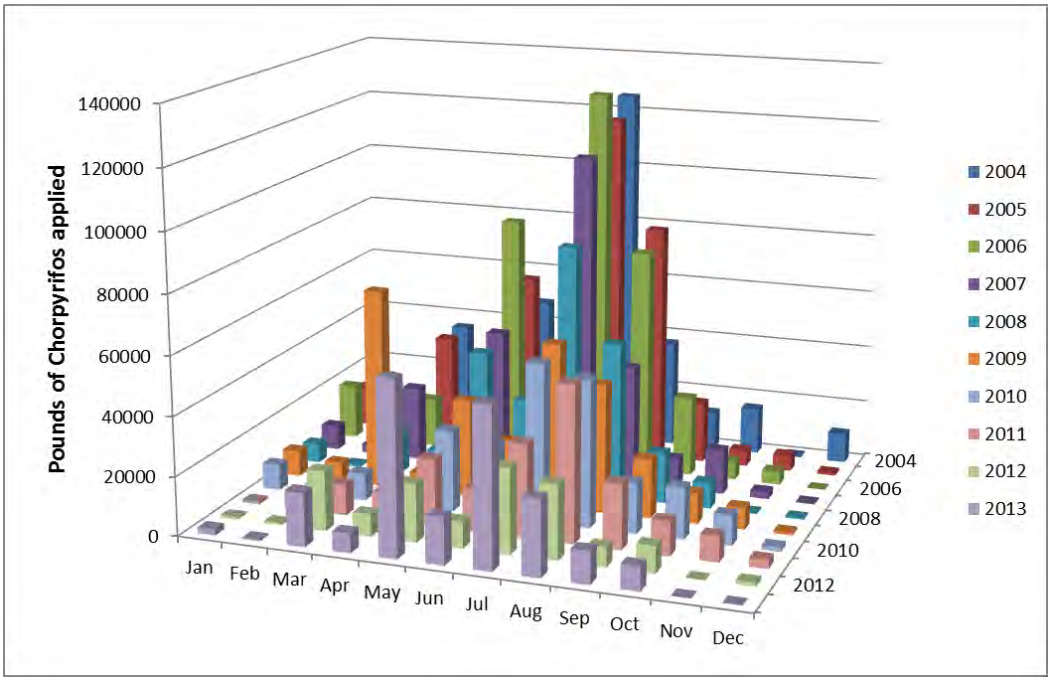
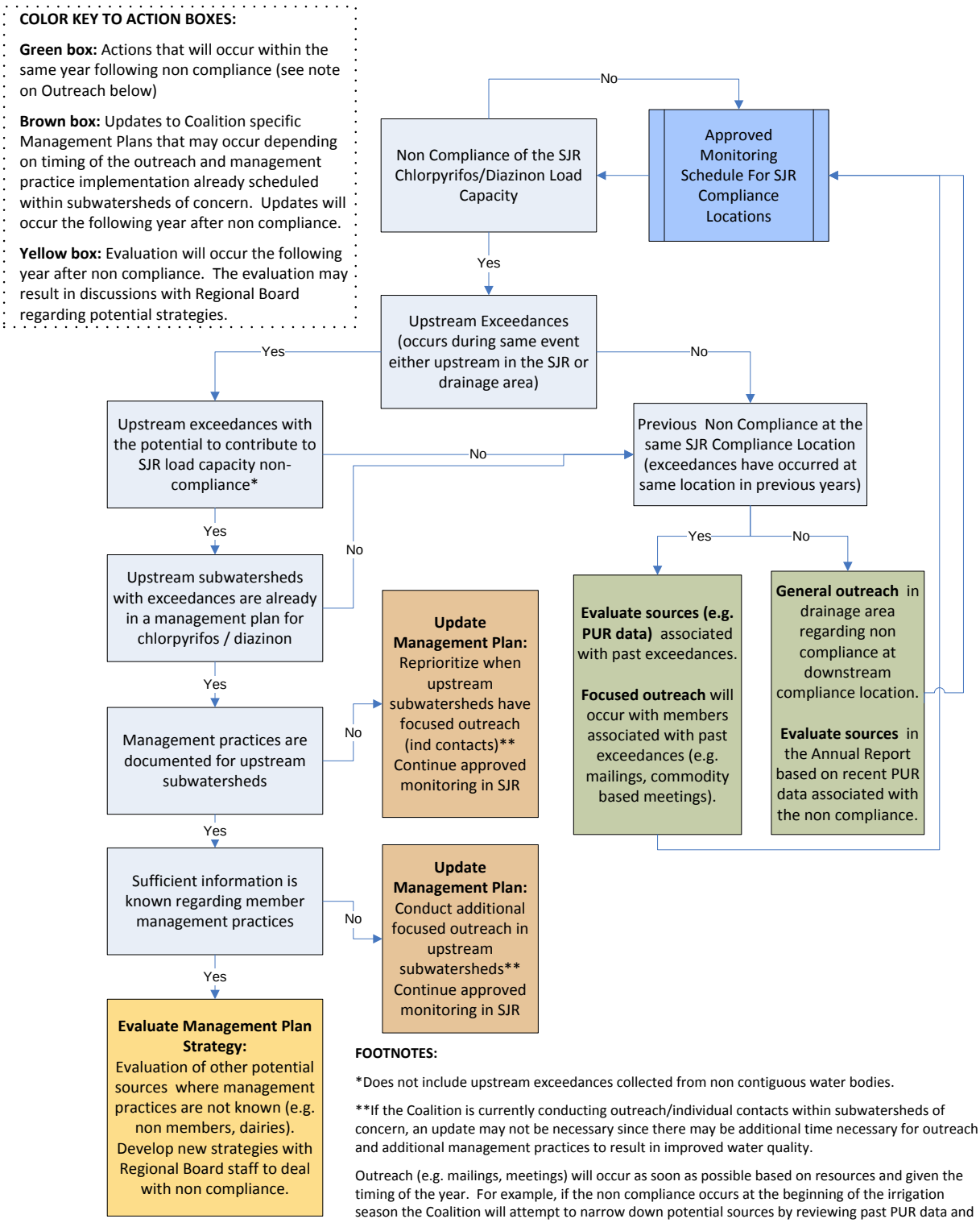


Figure 4. Chlorpyrifos and diazinon San Joaquin River TMDL Decision Tree for compliance monitoring and actions resulting from non-compliance of the San Joaquin River load capacity.



FOOTNOTES:

*Does not include upstream exceedances collected from non contiguous water bodies.

**If the Coalition is currently conducting outreach/individual contacts within subwatersheds of concern, an update may not be necessary since there may be additional time necessary for outreach and additional management practices to result in improved water quality.

Outreach (e.g. mailings, meetings) will occur as soon as possible based on resources and given the timing of the year. For example, if the non compliance occurs at the beginning of the irrigation season the Coalition will attempt to narrow down potential sources by reviewing past PUR data and inform those growers of the non compliance with the goal of improving SJR water quality during the rest of the high use period.

Constituents Monitored

Water samples collected from the lower SJR for the TMDL compliance program were analyzed for chlorpyrifos and diazinon. Habitat information and field parameter measurements, including dissolved oxygen (DO), pH, specific conductance (SC), and water temperature, were collected at each site during each monitoring event. Discharge calculations were obtained from Department of Water Resources (DWR) and/or United Stated Geological Survey (USGS) gauge readings posted on the California Data Exchange Center (CDEC) website. Samples collected by the Westside Coalition during monthly monitoring of the SJR compliance points were also analyzed for additional constituents for compliance with the ILRP as described in the Westside Coalition MRP. Results from ILRP monitoring (of both additional constituents analyzed in the SJR and tributary monitoring) are reported in the Westside SAMRs and the ESJWQC AMRs. The sampling procedures and analytical methods are further discussed in the Sampling and Analytical Methods section.

SAMPLE SITE DESCRIPTIONS

The Basin Plan Amendment requires the Coalitions to assess compliance with WQOs and loading capacity for, at a minimum, the six designated water quality compliance points on the SJR (Figure 5). The compliance points are listed from upstream to downstream:

- San Joaquin River at Sack Dam,
- San Joaquin River at Highway 165 near Stevinson (USGS 11260815),
- San Joaquin River at Hills Ferry Road,
- San Joaquin River at Las Palmas Avenue near Patterson (USGS 11274570),
- San Joaquin River at the Maze Boulevard (Highway 132) Bridge (USGS 11290500), and
- San Joaquin River at the Airport Way Bridge near Vernalis (USGS 11303500).

These compliance points are not named consistently in all sources used to prepare this report; hence Table 4 provides a crosswalk of the sites as they are named in other data sources.

Additionally, the Basin Plan Amendment specifies that compliance with load allocations for nonpoint source discharges into the SJR must be determined for the following five groups of tributary subareas (Figure 5):

- Bear Creek and Fresno-Chowchilla subareas
- Stevinson and Grassland subareas,
- Turlock, Merced, and Greater Orestimba subareas,
- Tuolumne River, Northeast Bank, and Westside Creek subareas, and
- Stanislaus River, North Stanislaus, and Vernalis North subareas.

Monitoring at five of the six compliance points on the SJR assesses drainage from these subareas (Table 4 and Figure 5). During the 2013 WY, the Coalitions collected samples from 37 tributaries (19 in ESJWQC region and 18 in Westside Coalition region). The SJR compliance sites and the associated tributaries that drain to each compliance point are listed in Table 5 and Figure 5. Although there are no tributaries listed that drain into San Joaquin River at Sack Dam, there is the potential for indirect drainage and spray drift to occur in a small area next to the river upstream of this monitoring location (Figure 5).

Results from ESJWQC and Westside Coalition tributary monitoring are discussed in this report as they pertain to SJR monitoring. Details of ESJWQC 2012 and 2013 tributary monitoring locations can be found in the ESJWQC AMR submitted March 1, 2013 and Annual Report submitted May 1, 2014. Westside Coalition tributary monitoring locations from October 2012 through August 2013 were reported in the Westside Coalition SAMRs submitted June 15 and November 30, 2013. Westside Coalition tributary monitoring locations from September 2013 will be reported in the Westside Coalition SAMR to be submitted June 15, 2013.

Table 4. San Joaquin River chlorpyrifos and diazinon compliance sites designated in the Basin Plan Amendment; subareas that drain to those sites; and a crosswalk of the station names as used in the appendices and electronic files of this report (Appendices Station Name and Code) and in California Environmental Data Exchange Network (CEDEN; Station Name and Code).

Listed in order from upstream to downstream.

Station name	Subareas	USGS ID No.	Appendices Station Name	Appendices Code	CEDEN Station Name	CEDEN Code	Latitude	Longitude	Coalition
San Joaquin River at Sack Dam	NA	NA	SJR @ Sack Dam	SJRSD	SJR @ Sack Dam	541MAD007	36.98361	-120.50028	Westside
San Joaquin River at Highway 165 near Stevinson	Bear Creek, Fresno-Chowchilla	11260815	SJR @ Hwy 165	SJRLA	San Joaquin River at Lander Ave	541MER522	37.29528	-120.85028	Westside
San Joaquin River at Hills Ferry Road	Stevinson, Grassland	NA	SJR @ Hills Ferry	541STC512	SJR @ Hills Ferry	541STC512	37.34250	-120.97722	ESJWQC
San Joaquin River at Las Palmas Avenue near Patterson	Turlock, Merced, Greater Orestimba	11274570	SJR @ Las Palmas Ave	SJRPP	SJR @ Patterson	541STC507[1]	37.49778	-121.08167	ESJWQC
					San Joaquin River at PID Pumps	541XSJRPP	37.49720	-121.08280	Westside
San Joaquin River at the Maze Boulevard (Highway 132) Bridge	Tuolumne River, Northeast Bank, Westside Creek	11290500	SJR @ Maze Blvd	541STC510	San Joaquin River above Maze Boulevard	541STC510	37.64194	-121.22778	ESJWQC
San Joaquin River at the Airport Way Bridge near Vernalis	Stanislaus River, North Stanislaus, Vernalis North	11303500	SJR @ Airport Way	541SJC501	San Joaquin River at Airport Way near Vernalis	541SJC501	37.67556	-121.26417	ESJWQC

NA – Not Applicable -Not applicable because this station is not identified as having drainage from subareas as listed in the Basin Plan amendment (see Figure 5). However, this report identifies some drainage possible along the river in the Fresno-Chowchilla and Grassland subareas (see Figure 5).

Table 5. The ESJWQC and Westside Coalition upstream tributary monitoring during 2013 WY and most immediate downstream SJR monitoring sites.

Organized by nearest downstream monitoring location.

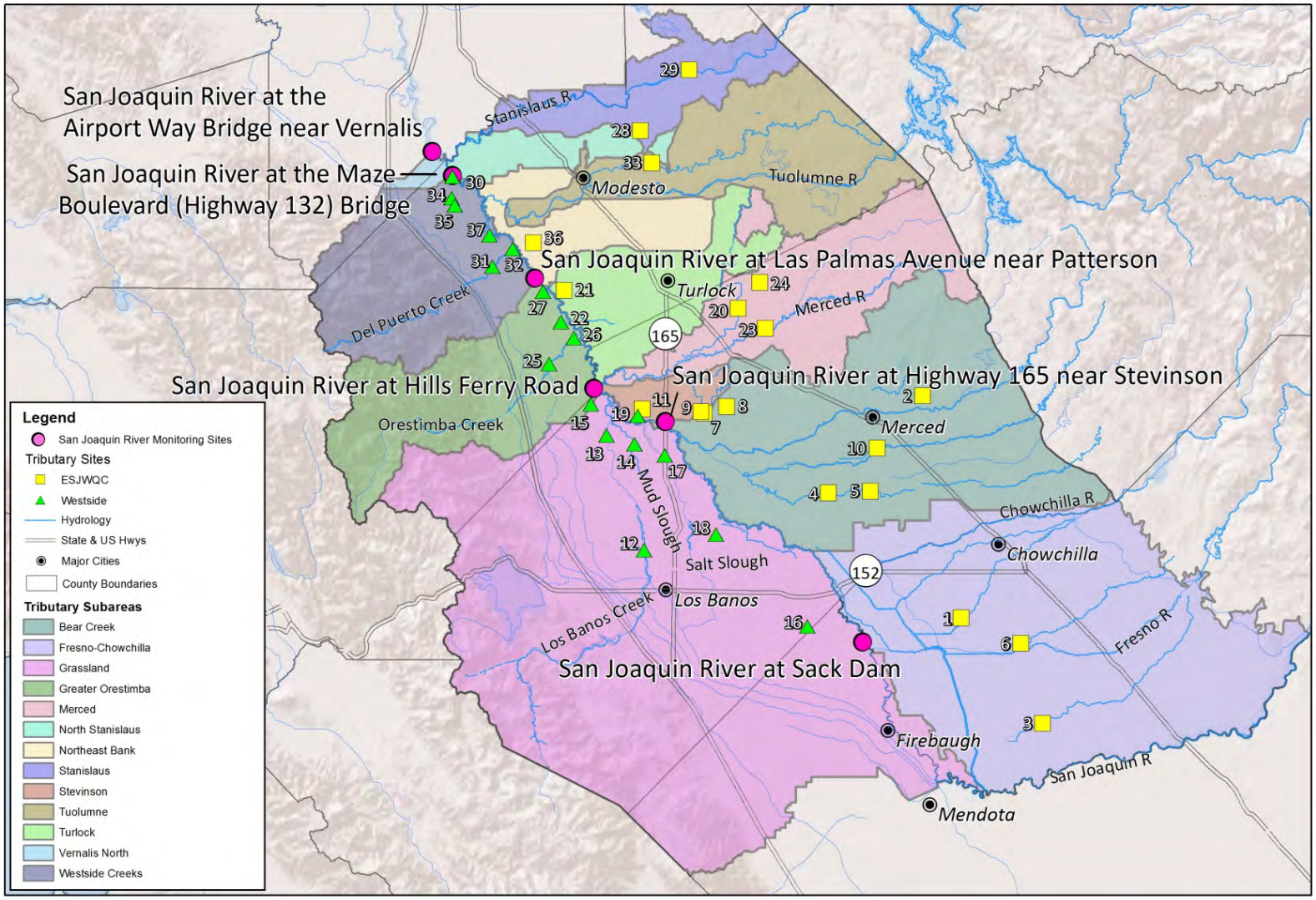
Coalition region	Map Key	Station Name	Station Code	Latitude	Longitude	SJR Downstream Monitoring Location
ESJWQC	1	Berenda Slough along Ave 18 1/2	545XBSAAE	37.0182	-120.3265	San Joaquin River at Highway 165 near Stevinson
ESJWQC	2	Black Rascal Creek @ Yosemite Rd	535BRCAYR	37.33202	-120.39435	
ESJWQC	3	Cottonwood Creek @ Rd 20	545XCCART	36.8686	-120.1818	
ESJWQC	4	Deadman Creek @ Gurr Rd	535XDCAGR	37.19514	-120.56147	
ESJWQC	5	Deadman Creek @ Hwy 59	535DMCAHF	37.19755	-120.48763	
ESJWQC	6	Dry Creek @ Rd 18	545XDCARE	36.9818	-120.22056	
ESJWQC	7	Howard Lateral @ Hwy 140	535XHLAHO	37.3079	-120.782	
ESJWQC	8	Livingston Drain @ Robin Ave	535XLDARA	37.31693	-120.74229	
ESJWQC	9	McCoy Lateral @ Hwy 140	535XMLAHO	37.30968	-120.78771	
ESJWQC	10	Miles Creek @ Reilly Rd	535XMCARR	37.2583	-120.47524	
ESJWQC	11	Unnamed Drain @ Hwy 140	535XUDAHO	37.313306	-120.892176	San Joaquin River at Hills Ferry Road
Westside	12	Los Banos Creek at China Camp Road	541XLBCCC	37.1145	-120.8895	
Westside	13	Los Banos Creek at Hwy 140	541MER554	37.2762	-120.9555	
Westside	14	Mud Slough Upstream of San Luis Drain	541XMSUSL	37.26388	-120.90611	
Westside	15	Newman Wasteway near Hills Ferry Road	541XNWHFR	37.3204	-120.9834	
Westside	16	Poso Slough at Indiana Ave	541XPSAIA	37.0062	-120.5996	
Westside	17	Salt Slough at Lander Ave	541MER531	37.2479	-120.8522	
Westside	18	Salt Slough at Sand Dam	541XSSASD	37.1366	-120.7619	
Westside	19	Turner Slough at Edminster Road	541XTSAER	37.3041	-120.9008	
ESJWQC	20	Highline Canal @ Lombardy Rd	535XHCALR	37.45547	-120.72181	San Joaquin River at Las Palmas Avenue near Patterson
ESJWQC	21	Levee Drain @ Carpenter Rd	535XLDACR	37.48062	-121.03106	
Westside	22	Marshall Road Drain near River Road	541XMRDRR	37.4363	-121.0362	
ESJWQC	23	Merced River @ Santa Fe	535XMRSFD	37.42705	-120.67353	
ESJWQC	24	Mustang Creek @ East Ave	535XMCAEA	37.4918	-120.6839	
Westside	25	Orestimba Creek at Hwy 33	541STC519	37.37715	-121.05812	
Westside	26	Orestimba Creek at River Road	541STC019	37.41388	-121.01417	
Westside	27	Ramona Lake near Fig Avenue	541XROLFA	37.4788	-121.0684	
ESJWQC	28	Mootz Drain downstream of Langworth Pond3	535XMDDLP	37.70539	-120.89569	San Joaquin River at the Airport Way Bridge near Vernalis
ESJWQC	29	Rodden Creek @ Rodden Rd	535XRCARD	37.79053	-120.80886	
Westside	30	Blewett Drain at Highway 132	541XVH132	37.64052	-121.2296	San Joaquin River at the Maze Boulevard (Highway 132) Bridge
Westside	31	Del Puerto Creek at Hwy 33	541XDPCHW	37.51421	-121.15875	
Westside	32	Del Puerto Creek near Cox Road	541XDPCCR	37.5394	-121.1221	
ESJWQC	33	Dry Creek @ Wellsford Rd	535XDCAWR	37.66	-120.87526	
Westside	34	Hospital Creek at River Road	541XHCARR	37.61047	-121.23078	
Westside	35	Ingram Creek at River Road	541STC040	37.60022	-121.22506	
ESJWQC	36	Lateral 2 ½ near Keyes Rd	535LTHNKR	37.54766	-121.08509	
Westside	37	Westley Wasteway near Cox Road	541XWWNCR	37.5582	-121.1637	

ESJWQC – East San Joaquin Water Quality Coalition

Map **Key – refer to Figure 5.**

Figure 5. San Joaquin River tributary subareas, Chlorpyrifos and Diazinon TMDL compliance sites (circles), and tributary sites monitored by ESJWQC (squares) and Westside Coalition (triangles) during the 2013 WY.

Refer to Table 4 for tributary station names.



Land Use Analysis of Subareas

The Coalitions reviewed land use using the United States Department of Agriculture (USDA) cropland data from 2013 to better characterize the upstream drainage area for each of the SJR monitoring compliance points (Table 6 and Table 7). The entire drainage area is estimated to include little over three million acres. Agriculture within the SJR basin includes orchard, pasture, rice, row crop, vineyards, and nursery/berries. Row crops and orchards cover the most area and together account for about 28% of estimated acreage.

Table 7 identifies the crop types with the largest acreage within the immediate upstream drainage to each monitoring site on the SJR. Almonds and alfalfa are among the three top crops by acreage throughout the region. In the upper portion of the lower SJR watershed, grapes occupy a large portion of acreage whereas various row crops and walnuts are more common in the lower area of the lower SJR watershed. Corn, cotton, oats, tomatoes, and winter wheat are also all very common in the lower SJR drainage area.

Land use maps for all ESJWQC upstream tributaries can be found in the 2014 Annual Report (Appendix VIII). A discussion of land use within the Westside Coalition is located in the November 30, 2013 SAMR (page 14).

Table 6. Estimated land use acreage upstream of the San Joaquin River compliance points.
Subwatershed totals reflect only immediate upstream acreage within the subareas that drain to each site.

Land Use	San Joaquin River at Sack Dam	San Joaquin River at Highway 165 near Stevinson	San Joaquin River at Hills Ferry Road	San Joaquin River at Las Palmas Avenue near Patterson	San Joaquin River at the Maze Blvd. (Highway 132) Bridge	San Joaquin River at the Airport Way Bridge
Barren	1,024	7,327	3,478	1,833	2,701	813
Developed	3,182	51,255	15,787	22,649	35,793	27,564
Fallow/Idle Cropland	449	12,964	5,527	12,802	7,283	4,853
Native	13,409	323,798	494,520	195,488	227,648	35,231
Open Water	3,100	4,942	22,074	2,424	9,676	3,011
Orchard	8,320	160,183	25,904	94,464	87,316	33,863
Pasture	9,019	103,139	80,336	43,450	30,392	28,334
Rice	65	3,613	7,762	25	1,186	567
Row Crop	17,058	153,015	174,903	80,507	35,310	13,786
Vineyard	15,142	97,442	2,602	12,523	6,227	2,216
Truck/Nursery/Berry	1,170	27,995	59,550	12,602	12,369	3,851
Outside study area	8,324	91,679	91,193	840	40,923	0
Estimated Subwatershed Total Acres	80,264	1,037,351	983,637	479,608	496,824	154,088
Estimated Cumulative Total Acres	80,264	1,117,615	2,101,252	2,580,861	3,077,685	3,231,773

Source: Acreages estimated from 2013 USDA data.

Table 7. Top ten commodities (based on acreage) upstream of each San Joaquin River sampling site for 2013 WY.

Listed in order of largest to smallest acreage.

San Joaquin River at Sack Dam	San Joaquin River at Highway 165 near Stevinson	San Joaquin River at Hills Ferry Road	San Joaquin River at Las Palmas Avenue near Patterson	San Joaquin River at the Maze Boulevard (Highway 132) Bridge	San Joaquin River at the Airport Way Bridge near Vernalis
Cotton	Almonds	Cotton	Almonds	Almonds	Almonds
Alfalfa	Alfalfa	Alfalfa	Corn	Corn	Corn
Almonds	Corn	Tomatoes	Alfalfa	Walnuts	Walnuts
Pistachios	Cotton	Corn	Beans	Alfalfa	Alfalfa
Tomatoes	Pistachios	Melons/Squash/Cucumbers	Walnuts	Tomatoes	Peaches/Nectarines
Oranges	Tomatoes	Almonds	Tomatoes	Peaches/Nectarines	Melons/Squash/ Cucumbers
Corn	Figs	Sugar Beets	Peaches/Nectarines	Beans	Beans
Walnuts	Sweet Potatoes	Beans	Sweet Potatoes	Apricots	Flowers/Nursery/ Christmas Tree Farms
Sudan	Peaches/Nectarines	Sudan	Melons/Squash/ Cucumbers	Sudan	Tomatoes
Plums	Oranges	Walnuts	Apricots	Cherries	Apples

Source: Acreages estimated from 2013 USDA data.

RAINFALL RECORDS

Daily rainfall records are provided for four locations within the ESJWQC and Westside Coalition regions: Modesto, Merced, Los Banos, and Patterson. Precipitation records were retrieved from the California Irrigation Management Information System (CIMIS). The 2013 WY included few significant storms and has been classified as a critically dry year type. Measurable precipitation first occurred in the second half of October with periodic storms occurring throughout the winter months interrupted by dry periods (Figure 6 and Figure 7).

From October 2012 through September 2013, a few rainfall events produced enough runoff across the lower SJR drainage area for storm sample collection. The ESJWQC collected storm samples at tributary sites on December 3, 2012, and April 2, 2013; and at the three TMDL compliance locations on February 20, 2013. Storm samples were collected in the Westside Coalition region at both tributary and TMDL compliance locations on January 8, 2013.

Figure 6. Precipitation history from October 1, 2012 through March 31, 2013.

Data recorded at CIMIS stations in Modesto, Merced, Los Banos and Patterson, CA

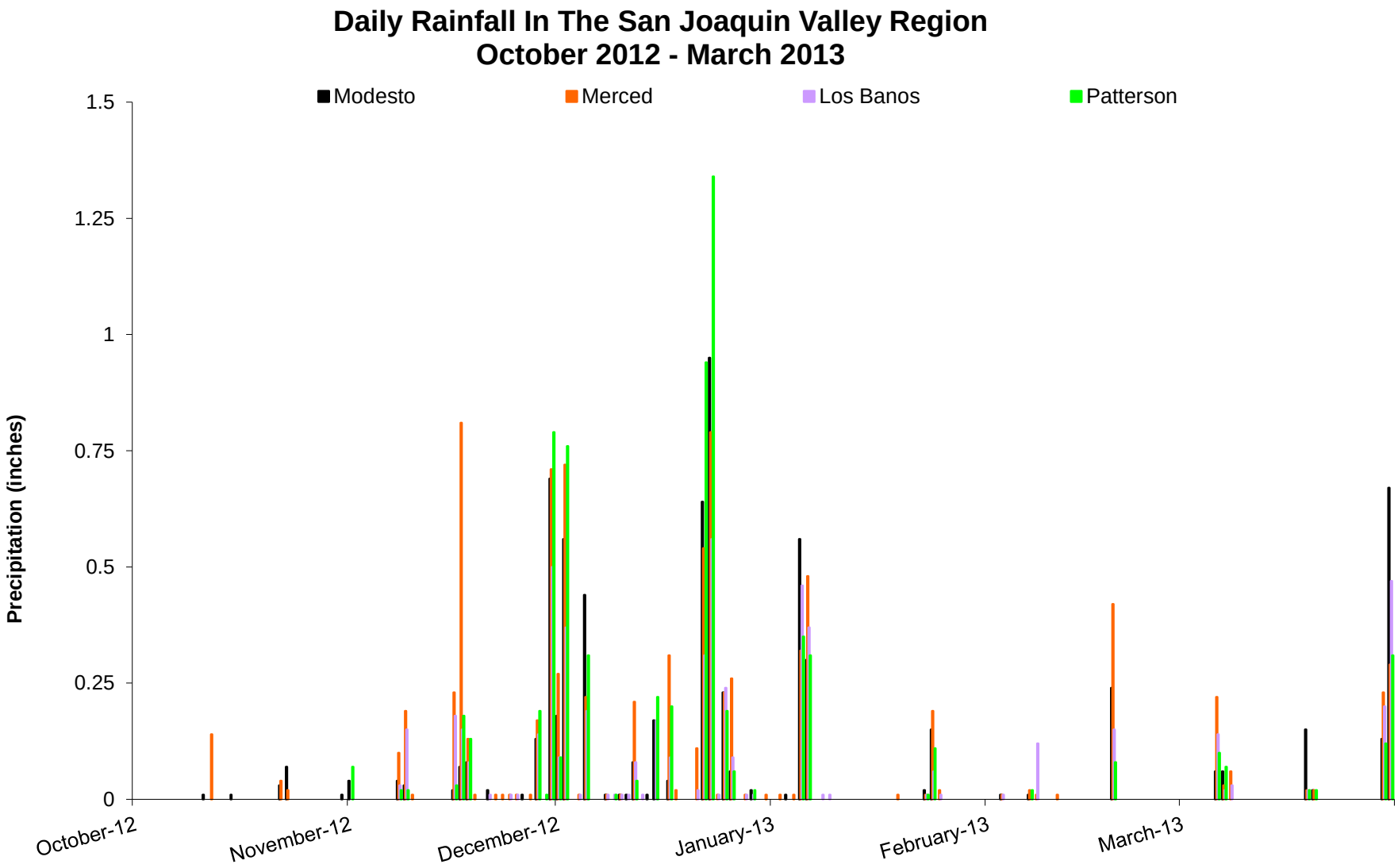
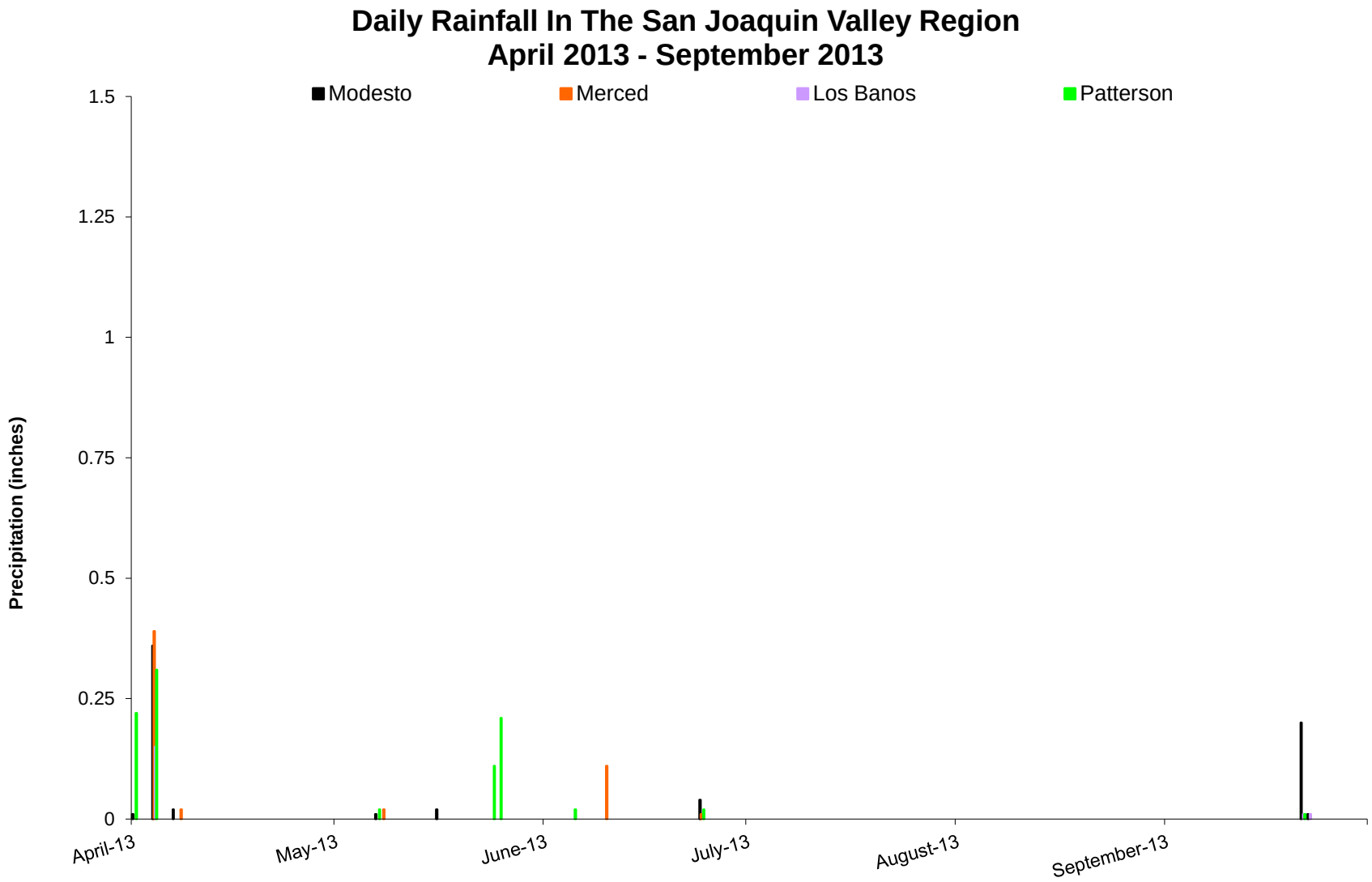


Figure 7. Precipitation history from April 1 through September 30, 2013.

Data recorded at CIMIS stations in Modesto, Merced, Los Banos and Patterson, CA.



SAMPLING AND ANALYTICAL METHODS

Information on sample collection containers, volumes, preservations and holding times is provided in Table 8 and field instrument information in Table 9. Site-specific discharge methods are described in Table 10, and analytical methods and reporting limits (RL) are provided in Table 11.

Field sampling procedures and methods were performed at the San Joaquin River at the Airport Way Bridge near Vernalis, San Joaquin River at Hills Ferry Road and San Joaquin River at the Maze Boulevard (Highway 132) Bridge as outlined in the standard operating procedures (SOPs) provided in the ESJWQC QAPP (amendment submitted on February 15, 2013 (approval pending), Appendices I-X, pages 63-98). The ESJWQC field samplers collected an integrated river water sample using a three liter polytetrafluoroethylene (PFTE) bottle from a bridge crossing. Amber glass bottles were filled from the integrated sample collected in the PFTE bottle.

The Westside Coalition sampled the San Joaquin River at Fremont Ford, San Joaquin River at Highway 165 near Stevinson, San Joaquin River at Las Palmas Avenue near Patterson and San Joaquin River at Sack Dam according to the field sampling procedures and methods described in the Westside Coalition QAPP (approved January 7, 2014, Pages 24-29). The Westside Coalition field samplers collected sample water directly into amber glass bottles from the SJR bank at each site. Due to safety concerns, Westside Coalition samplers do not perform bridge sampling.

The complete field sampling SOPs for the Westside Coalition and the ESJWQC were included in Appendix I of the San Joaquin River Chlorpyrifos and Diazinon 2010 AMR (submitted October 31, 2010); no deviations from these procedures occurred during monitoring for the 2013 WY. Samples from both Coalitions were analyzed for chlorpyrifos and diazinon by APPL Inc. laboratory according to Environmental Protection Agency (EPA) 8141A method. The SOPs for the EPA 8141A method were submitted with both Coalitions' QAPPs as Appendix XII to the ESJWQC QAPP (Pages 133-155) and with the Westside Coalition QAPP (Appendix D, Attachment 7).

In addition to SJR monitoring data, both Coalitions use tributary monitoring data (where applicable) to assess compliance with the TMDL program. The ESJWQC performed field sampling procedures and methods, including discharge measurements at tributaries as outlined in the SOPs provided with the ESJWQC QAPP (Appendices I-X, Pages 63-98). Any deviations from these procedures are documented in the Precision, Accuracy and Completeness section of this report.

The Westside conducted field sampling procedures and methods, including discharge measurements, at tributaries as described in the Westside Coalition QAPP (Appendix B); no deviations from these procedures occurred during the monitoring. The laboratory procedures used to analyze samples collected from ESJWQC tributaries are contained in Appendices XI-XXXIII of the ESJWQC QAPP (Pages 108-394). The laboratory procedures used to analyze samples collected from Westside Coalition tributaries can be found in the Westside Coalition QAPP (Appendix D, Attachment 7).

Table 8. Sampling procedures, containers, sample volumes, preservation and storage techniques, and holding times.

Analytical Parameter	Sample Volume[1]	Sample Container	Initial Preservation/Holding Requirements	Holding Time[2]
Organophosphates	1 L	1x L Amber Glass	Store at <6°C; extract within 7 days	40 Days

[1] Additional volume may be required for Quality Control (QC) analyses.
[2] Holding time after initial preservation or extraction.

Table 9. Field parameters and instruments used to collect measurements.

Parameter	Instrument
Dissolved Oxygen	YSI Model 556/Professional Plus
Temperature	YSI Model 556/Professional Plus
pH	YSI Model 556/Professional Plus
Specific Conductance	YSI Model 556/Professional Plus
Discharge	DWR or USGS Gauge/CDEC Website[1]

[1] DWR – California Department of Water Resource; USGS – United States Geological Survey /CDEC – California Data Exchange Center

Table 10. Site specific discharge methods.

Responsible Coalition	Station name	Discharge Method	Gauge
Westside	San Joaquin River at Sack Dam	DWR Gauge	CDEC San Joaquin River near Dos Palos (SDP)
Westside	San Joaquin River at Highway 165 near Stevinson	DWR Gauge	CDEC San Joaquin River near Stevinson (SJS)[1]
ESJWQC	San Joaquin River at Hills Ferry Road	USGS and DWR Gauge	CDEC San Joaquin River Near Newman (NEW)
Westside	San Joaquin River at Las Palmas Avenue near Patterson	DWR Gauge	CDEC San Joaquin River near Patterson (SJP)
ESJWQC	San Joaquin River at the Maze Boulevard (Highway 132) Bridge	DWR Gauge	CDEC San Joaquin River at Maze Rd Bridge (MRB)
ESJWQC	San Joaquin River at the Airport Way Bridge near Vernalis	USGS and DWR Gauge	CDEC San Joaquin River near Vernalis (VNS)

[1] Data for this gauge station is unavailable from March 5, 2010 through December 6, 2011. Station SMN (San Joaquin River above Merced River) is used where SJS data are not available.
CDEC – California Data Exchange Center
DWR – Department of Water Resources
ESJWQC – East San Joaquin Water Quality Coalition
USGS – United States Geological Survey

Table 11. Field and laboratory analytical methods.

Constituent	Matrix	Analyzing Lab	RL	MDL	Analytical Method
Physical Parameters					
pH	Water	Field Measure	0.1 pH units	NA	EPA 150.1
Specific Conductance	Water	Field Measure	100 µmhos/cm	NA	EPA 120.1
Dissolved Oxygen	Water	Field Measure	0.1 mg/L	NA	SM 4500-O
Temperature	Water	Field Measure	0.1 °C	NA	SM 2550
Organophosphates					
Chlorpyrifos	Water	APPL Inc	0.015 µg/L	0.0026 µg/L	EPA 8141A
Diazinon	Water	APPL Inc	0.02 µg/L	0.004 µg/L	EPA 8141A

RL – Reporting Limit
MDL – Minimum Detection Limit
NA – Not Applicable
EPA - Environmental Protection Agency
SM – Standard Method

MONITORING RESULTS

This section includes all SJR monitoring data collected from October 2012 through September 2013.

Complete and accurate records of sample handling and processing is found in the Chain of Custody (COC) forms. These are faxed by the laboratories to Michael L. Johnson, LLC (MLJ-LLC) and Summers Engineering after receipt of samples. The COCs document the timing of sample collection and delivery to the laboratories. Appendix I contains copies of the original COC forms. If there are any discrepancies between the COC and sample delivery, the issues are resolved and documented directly on the COC.

Complete monitoring results from sampling conducted at the compliance points on the SJR are included in Appendix II and III. Appendix II contains the monitoring results for field parameters (DO, SC, pH, temperature and discharge) and laboratory analyses for chlorpyrifos and diazinon. Appendix III contains field and laboratory Quality Assurance/Quality Control (QA/QC) data, including results from field duplicate (FD) and blank (FB), laboratory duplicate and blank, laboratory control spike (LCS) and matrix spike (MS). QA data are discussed in the Precision, Accuracy and Completeness section.

Loading capacity and compliance were determined for all environmental samples collected from the SJR during the reporting period. Loading capacities and compliance status are reported in Appendix IV (Table IV-1) and discussed in the Comparison with TMDL Objectives section of this report.

All original field data sheets can be found in Appendix V. Appendix VI contains monitoring site photos from all events. All associated laboratory reports (as pdfs) are submitted along with this report.

Results from ESJWQC and Westside Coalition tributary monitoring, and the outcomes of each Coalition's management plan strategies are discussed in this report as they pertain to assessing compliance with the chlorpyrifos and diazinon TMDL. Details of ESJWQC 2012 and 2013 tributary monitoring results can be found in the ESJWQC AMR submitted March 1, 2013 and ESJWQC Annual Report submitted May 1, 2014. The status and most recent results of the ESJWQC management plan strategy were reported in the MPUR submitted April 1, 2013 and May 1, 2014. Westside Coalition tributary monitoring results from October 2012 through August 2013 and management plan status and activities during this period were reported in the Westside Coalition SAMRs submitted June 15 and November 30, 2013 (Attachment 6 in both reports). Westside Coalition tributary monitoring results from September 2013 will be reported in the Westside Coalition SAMR to be submitted June 15, 2014.

SAMPLE DETAILS

Table 12 lists sample dates for each SJR sampling location, and tributaries in both coalitions' areas. Sampling times for these events are found in the Appendix II. In accordance with its standard monitoring schedule, the Westside Coalition collected samples monthly at San Joaquin River at Sack Dam, San Joaquin River at Highway 165 near Stevinson, and San Joaquin River at Las Palmas Avenue near Patterson. The ESJWQC collected samples at San Joaquin River at the Maze Boulevard (Highway 132) Bridge, San Joaquin River at Hills Ferry Road, and San Joaquin River at the Airport Way Bridge near

Vernalis during six events (one storm event during February and monthly from May through September 2013). The 2013 WY was a critically dry water year type and few of the storms produced sufficient precipitation to cause substantial runoff across the entire lower SJR watershed. Storm samples were collected for both Coalitions at SJR compliance locations and tributary sites on January 8 (Westside Coalition) and February 20 (ESJWQC) during the 2013 WY (Table 12). However, samples were not collected at San Joaquin River at Las Palmas Avenue near Patterson during the January 8, 2013 storm monitoring event. Both Coalitions conducted monthly tributary monitoring during the 2013 WY.

Table 12. Dates of monitoring at San Joaquin River and upstream tributary sites during the 2013 WY.

Monitoring by the Westside Coalition (WC) and the ESJWQC (ES) was done during storm events (Storm), and Irrigation events (Irr) and non-irrigation events (NI).

Year	Month	Day	San Joaquin River above Maze Boulevard	San Joaquin River at Airport Way near Vernalis	SJR @ Hills Ferry	San Joaquin River at Highway 165 near Stevinson	San Joaquin River at Las Palmas Avenue near Patterson	San Joaquin River at Sack Dam	Westside Tributaries	ESJWQC Tributaries
2012	Oct	9								ES
		16				WC-NI	WC-NI	WC-NI	WC	
	Nov	13				WC-NI	WC-NI	WC-NI	WC	ES
	Dec	3								ES-Storm
		11				WC-NI	WC-NI	WC-NI	WC	
2013	Jan	8				WC-Storm	NA[1]	WC-Storm	WC-Storm	ES
	Feb	12				WC-NI	WC-NI	WC-NI	WC	ES
		20	ES-Storm	ES-Storm	ES-Storm					ES
	Mar	12				WC-Irr	WC-Irr	WC-Irr	WC	ES
	Apr	2								ES-Storm
		9				WC-Irr	WC-Irr	WC-Irr	WC	ES
	May	14	ES-Irr	ES-Irr	ES-Irr	WC-Irr	WC-Irr	WC-Irr	WC	ES
	Jun	11	ES-Irr	ES-Irr	ES-Irr	WC-Irr	WC-Irr	WC-Irr	WC	ES
	Jul	9	ES-Irr	ES-Irr	ES-Irr	WC-Irr	WC-Irr	WC-Irr	WC	ES
	Aug	13	ES-Irr	ES-Irr	ES-Irr	WC-Irr	WC-Irr	WC-Irr	WC	ES
	Sept	10	ES-Irr	ES-Irr	ES-Irr	WC-Irr	WC-Irr	WC-Irr	WC	ES

[1] Sample not collected

PRECISION, ACCURACY AND COMPLETENESS

An assessment of precision, accuracy, and completeness is tabulated in Table 13 through 15. All data are acceptable and useable. In a few instances, some data quality objectives were not met, but these do not affect the usability of data.

All results are tabulated in Appendix II (Monitoring Results) and Appendix III (Field and Laboratory QA Results). A result is flagged if it does not meet data quality objectives (acceptability criteria) using Surface Water Ambient Monitoring Program (SWAMP) codes. Results are maintained in the SWAMP comparable database managed by the Central Valley Regional Data Center (CV RDC). The Coalitions work with the CV RDC to ensure all data remain SWAMP comparable and all data are suitable to be uploaded to the CEDEN. A copy of the SWAMP comparable database is submitted to the Regional Board with the hardcopy of this report. The database and spreadsheets include all data from October 2012 through September 2013 sampling.

COMPLETENESS

Completeness is assessed on three levels: field and transport completeness, analytical completeness, and batch completeness. Field and transport completeness assesses how many of the scheduled samples were collected and sent for analysis. Field and transport completeness may be less than 100% for reasons such as bottle breakage during transportation or inability to access a site. Analytical completeness assesses the number of samples that arrived at a laboratory and were analyzed. Analytical completeness may be less than 100% for various reasons including bottle breakage while the sample was stored at the laboratory or laboratory error resulting in an analysis not being performed. Batch completeness assesses whether chemistry batches have all required laboratory Quality Control (QC). For batch completeness, the number of batches with complete laboratory QC is compared to the overall number of batches. Table 13 includes an evaluation of completeness for the various levels.

Field and Transport Completeness

Field and transport completeness is calculated by dividing the number of samples collected by the number of samples scheduled to be collected for each analyte. All sites and constituents were monitored as scheduled during the 2013 WY with the single exception of monitoring at the San Joaquin River at Las Palmas near Patterson site during the January 2013 event (98% completeness). Monitoring occurred at the San Joaquin River at Sack Dam and San Joaquin River at Lander Avenue sites 12 times each and the San Joaquin River at Las Palmas site 11 times. The San Joaquin River at the Maze Boulevard (Highway 132) Bridge, San Joaquin River at the Airport Way Bridge near Vernalis and San Joaquin River at Hills Ferry Road sites were sampled six times each.

Field blanks and field duplicates were taken during each sampling event such that there is a set of QC samples associated with each Coalition's three sites; field blanks and field duplicates comprised 20% of the samples collected during the 2013 WY by the ESJWQC and Westside Coalitions (Table 13). Field

parameter measurements, including DO, discharge, pH, SC and water temperature were taken at each site sampled. Dissolved oxygen, discharge, pH, SC and water temperature were each measured 55 times (98%, Table 13).

Because the ESJWQC and Westside Coalition share sampling responsibilities, each Coalition was responsible for three sites per sampling event, and each Coalition collected its own set of field QC samples. The Westside Coalition and ESJWQC use the same methods for sample collection in the SJR as they use for sample collection from tributary sites in their respective regions (field sampling SOPs included in Appendix I of the San Joaquin River Chlorpyrifos and Diazinon 2010 AMR). Field and lab QC samples may be collected from tributaries or the SJR as long as all samples are collected on the same day during the same sampling event.

Analytical Completeness

All samples collected were preserved and analyzed, resulting in 100% analytical completeness (Table 13).

Table 13. The ESJWQC and Westside Coalition sample counts, field QC counts, and percentages.

Method	Analyte	Env. Samples Scheduled (#)	Env. Samples Collected (#)	Field and Transport Completeness (%)	Env. Samples Analyzed (#)	Env. Samples Completeness (%)	Env. and Field QC Samples (#)	Field Blanks (#)	Field Blanks (%)	Field Dup. (#)	Field Dup. (%)
EPA 8141A OP	Chlorpyrifos	56	55	98%	55	100%	91	18	20%	18	21%
EPA 8141A OP	Diazinon	56	55	98%	55	100%	91	18	20%	18	21%
CDEC at CRS	Discharge, cfs	56	55	98%	NA	NA	NA	NA	NA	NA	NA
SM 4500-O	DO, mg/L	56	55	98%	NA	NA	NA	NA	NA	NA	NA
EPA 150.1	pH	56	55	98%	NA	NA	NA	NA	NA	NA	NA
EPA 120.1	SC, µS/cm	56	55	98%	NA	NA	NA	NA	NA	NA	NA
SM 2550	Water Temperature, Degree C°	56	55	98%	NA	NA	NA	NA	NA	NA	NA
	Total	**392**	**385**	**98%**	**106**	**100%**	**182**	**36**	**21%**	**36**	**21%**

CDEC - California Data Exchange Center
CRS-Cressy flow gage station
DO – Dissolved Oxygen
EPA – Environmental Protection Agency
NA – Not Applicable
OP – Organophosphorus
SC – Specific Conductivity
SM – Standard Method

Batch Completeness

All chemistry batches were reviewed for Quality Assurance/Control (QA/QC) completeness. A complete batch must have a minimum of one laboratory blank (method blank), one laboratory duplicate, one LCS and one MS. Chemistry batch completeness was 100%.

Samples collected by the ESJWQC as part of monthly monitoring are recorded in the CV RDC database under a different project than are samples collected for the San Joaquin River Chlorpyrifos and Diazinon TMDL. If a sample collected from an ESJWQC tributary site is used as a MS for samples collected from

the SJR, the MS is labeled as a non-project (NONPJ) MS. All NONPJ MS samples listed in Appendix III were collected in ESJWQC tributaries and can be used to evaluate the accuracy and/or precision of a lab batch containing samples collected by the ESJWQC. San Joaquin River samples collected by the Westside Coalition are included as part of the Westside Coalitions ILRP compliance monitoring and are grouped as a single project.

HOLD TIME COMPLIANCE

Hold times for all chemistry analyses were met with the exception of one diazinon FD sample; overall, hold time compliance for all chemistry analysis was 99.5% (Table 14). Diazinon was found at an elevated concentration in the FD sample from the February 20, 2013 sampling event. The laboratory re-extracted and re-analyzed the FD for diazinon 16 days outside of hold time due to laboratory contamination in the original batch. Diazinon was detected in the re-extracted sample at concentrations ten times less than the original extraction. Due to laboratory contamination in the original batch, the Coalition is using data from the re-extracted sample and have flagged the sample as outside of hold time. Overall, diazinon met the hold time criteria for 99% of all samples analyzed and therefore data are considered acceptable.

Table 14. The ESJWQC and Westside Coalition summary of holding time evaluations for environmental, FB, FD, and MS samples.

Method	Analyte	Data Quality Objective	Number of Samples	Samples Within Control Limits	Percent Samples Acceptable
EPA 8141A OP	Chlorpyrifos	7 days	109	109	100%
EPA 8141A OP	Diazinon	7 days	109	108	99%
		Total	**218**	**217**	**99.5%**

EPA – Environmental Protection Agency
OP –Organophosphorus Compounds

SUMMARY OF PRECISION AND ACCURACY

Table 15 includes a review of the number of samples analyzed and the percentage of samples per analyte that meet acceptability criteria. Precision and accuracy criteria were met for 99% of the samples for all analytes and all criteria; all data are accepted and useable.

One hundred percent of field blanks and field duplicates met acceptability criteria.

Lab blanks were run with each batch, and 100% of the samples met acceptability criteria. Diazinon was detected in the ESJWQC February 20, 2013 laboratory blank. The laboratory re-extracted and re-analyzed the sample and diazinon was non-detect.

Surrogates were run with each pesticide analysis. Surrogate recoveries related to chlorpyrifos and diazinon analyses for the SJR sites were within specific acceptance criteria for 98% of all samples analyzed (Table 15). The tributylphosphate and triphenylphosphate surrogates from the October 2012 and November 2012 samples from the San Joaquin River at Sack Dam site were recovered above the

acceptable limits. One triphenylphosphate surrogate from the April 2013 samples for the Poso Slough at Indiana Ave site recovered above the QC limit. One triphenylphosphate surrogate and one tributylphosphate surrogate from the July 2013 QC samples recovered above the QC limit. The surrogates that recovered outside of acceptability criteria and the associated environmental samples were flagged accordingly.

Matrix spikes and LCSs were performed for each batch to assess accuracy and possible matrix interference. One hundred percent of all MS samples analyzed recovered within acceptable criteria. Ninety-seven percent of all LCS samples analyzed recovered within acceptable criteria. Chlorpyrifos LCS samples met 100% acceptable criteria, and 98% (31 of 32) of diazinon LCS samples met acceptable criteria (Table 15). A single diazinon laboratory control spike duplicate (LCSD) sample was recovered above the QC limit associated with the July 2013 Westside Coalition samples.

Laboratory precision assessed by the relative percent difference (RPD) of laboratory duplicates met acceptability criteria in 100% of MSDs and 100% of LCSDs samples (Table 15).

Table 15. The ESJWQC and Westside Coalition summary of QA/QC evaluations.

Sample Type Code	Method	Analyte	Data Quality Objective	Number of Samples	Samples Within Control Limits	Percent Samples Acceptable
Field Blank	EPA 8141A OP	Chlorpyrifos	<RL or < (env sample/5)	18	18	100%
Field Blank	EPA 8141A OP	Diazinon	<RL or < (env sample/5)	18	18	100%
			Field Blank Total	**36**	**36**	100%
Field Dup	EPA 8141A OP	Chlorpyrifos	RPD ≤ 25	18	18	100%
Field Dup	EPA 8141A OP	Diazinon	RPD ≤ 25	18	18	100%
			Field Dup Total	**36**	**36**	100%
Lab Blank	EPA 8141A OP	Chlorpyrifos	<RL	24	24	100%
Lab Blank	EPA 8141A OP	Diazinon	<RL	24	24	100%
			Lab Blank Total	**48**	**48**	100%
Surrogate	EPA 8141A OP	Tributylphosphate (Surrogate)	PR 60-150	181	178	98%
Surrogate	EPA 8141A OP	Triphenyl phosphate (Surrogate)	PR 56-129	181	177	98%
			Surrogate Total	**362**	**355**	98%
MS and MSD	EPA 8141A OP	Chlorpyrifos	PR 61-125	36	36	100%
MS and MSD	EPA 8141A OP	Diazinon	PR 57-130	36	36	100%
			MS Total	**72**	**72**	100%
MSD pairs	EPA 8141A OP	Chlorpyrifos	RPD ≤ 25	18	18	100%
MSD pairs	EPA 8141A OP	Diazinon	RPD ≤ 25	18	18	100%
			MSD Total	**36**	**36**	100%
LCS and LCSD	EPA 8141A OP	Chlorpyrifos	PR 61-125	32	32	100%
LCS and LCSD	EPA 8141A OP	Diazinon	PR 57-130	32	31	97%
			LCS Total	**64**	**63**	98%
LCSD pairs	EPA 8141A OP	Chlorpyrifos	RPD ≤ 25	8	8	100%
LCSD pairs	EPA 8141A OP	Diazinon	RPD ≤ 25	8	8	100%
			LCSD Total	**16**	**16**	**100%**

EPA - Environmental Protection Agency
LCS – Laboratory Comtrol Spike
LCSD – Laboratory Control Spike Duplicate
MS – Matrix Spike
MSD – Matrix Spike Duplicate
OP – Organophosphorus Compounds
PR – Percent Recovery
RL – Reporting Limit
RPD – Relative Percent Difference

Corrective Actions

Corrective actions were performed by the laboratories as outlined in the ESJWQC QAPP (submitted on February 15, 2013) and in the Westside Coalition QAPP (January 7, 2014) for QA/QC results that did not meet acceptance criteria for the 2013 WY. The necessary corrective actions are listed in Table 15 and Table 16 of the ESJWQC QAPP (pages 46-51) and in Table B-2a and B-2b of the Westside Coalition QAPP (Pages 39-40). If corrective actions occurred (e.g. reanalysis), details are included in the above sections and summarized below.

Diazinon was detected in the FD sample from the February 20, 2013 ESJWQC monitoring event. The laboratory re-extracted and re-analyzed the sample outside of hold time due to laboratory contamination; diazinon was ten times less than the original extraction in the FD.

COMPARISON WITH TMDL OBJECTIVES

The Lower San Joaquin River chlorpyrifos and diazinon TMDL objectives include:

1. Determine compliance with established water quality objectives (WQOs) and the loading capacity applicable to diazinon and chlorpyrifos in the SJR.
2. Determine compliance with established load allocations for diazinon and chlorpyrifos.
3. Determine the degree of implementation of management practices to reduce off-site movement of diazinon and chlorpyrifos.
4. Determine the effectiveness of management practices and strategies to reduce off-site migration of diazinon and chlorpyrifos.
5. Determine whether alternatives to diazinon and chlorpyrifos are causing surface water quality impacts.
6. Determine whether the discharge causes or contributes to toxicity impairment due to additive or synergistic effects of multiple pollutants.
7. Demonstrate that management practices are achieving the lowest pesticide levels technically and economically achievable.

The monitoring of the six compliance points in the SJR during the 2013 WY was designed to assess compliance with Objective 1. Objectives 2 through 7 are addressed individually by each Coalition through an assessment of results and outcomes of actions taken (e.g. monitoring and outreach) to meet the specifications of either Coalition's ILRP monitoring program. The following sections assess the ESJWQC's and Westside Coalition's compliance with the seven TMDL objectives.

OBJECTIVE 1: DETERMINE COMPLIANCE WITH ESTABLISHED WATER QUALITY OBJECTIVES AND THE LOADING CAPACITY APPLICABLE TO DIAZINON AND CHLORPYRIFOS IN THE SAN JOAQUIN RIVER.

Water Quality Objectives

During 2013, the Coalitions evaluated compliance with the chlorpyrifos and diazinon WQOs by reviewing monitoring results from the SJR compliance points listed in Table 4. In 2013, a single sample collected during the March 2013 monitoring event from San Joaquin River at Las Palmas Avenue near Patterson had detections above the WQO for chlorpyrifos (Table 16). Aside from the single exceedance, no other detections of chlorpyrifos or diazinon occurred in samples collected from the SJR during the 2013 WY. Complete environmental monitoring results are listed in Appendix II; complete QC monitoring results (including field duplicates), are listed in Appendix III.

Table 16. Exceedances of the WQO for chlorpyrifos at San Joaquin River sites during the 2013 WY.

Station Name	Sample Date	Sample Time	Analyte	Result (µg/L)	WQO (µg/L)
San Joaquin River at Las Palmas Avenue near Patterson	3/12/13	15:30	Chlorpyrifos	0.038	0.015

Loading Capacity

Loading capacity was calculated using the formula in Figure 1. One sample collected from San Joaquin River at Las Palmas Avenue near Patterson during March 2013 was out of compliance with loading capacity due to an exceedance of the WQO for chlorpyrifos (Table 17). Chlorpyrifos and diazinon were not detected in any other sampled collected from the SJR sample sites (Appendix IV, Table IV-1).

Table 17. Chlorpyrifos and diazinon loading capacity calculations for San Joaquin River sites out of compliance during the 2013 WY.

Station Name	Sample Date	Chlorpyrifos	Diazinon	Load	Load Allocation Compliance
San Joaquin River at Las Palmas Avenue near Patterson	3/12/13	0.038	<0.004	2.53	Out of compliance

The Basin Plan Amendment required compliance with the loading capacity for the chlorpyrifos and diazinon TMDL in the lower SJR by December 1, 2010. Table 18 includes a tally of the number of samples in compliance with the SJR loading capacity before and after that date. Prior to the compliance date, 13 samples (93%) collected from the SJR compliance locations were out of compliance with the loading capacity (Table 18). Since the compliance date, 99% of the samples collected by the ESJWQC and Westside Coalition from the SJR have been in compliance with loading capacity.

Overall, 345 samples have been collected from the SJR compliance points since July 2004, and 96% have been compliant with the load capacity (Table 18).

Table 18. Tally of chlorpyrifos and diazinon TMDL load capacity compliance per site (December 2010 through September 2013).

Station name	Sample Dates	Compliant	Out of Compliance	Total Samples Collected	Percent Compliant
After Compliance Date (Dec. 1, 2010)					
San Joaquin River at Sack Dam	Dec 2010 - Sept 2013	33	0	33	100%
San Joaquin River at Highway 165 near Stevinson	Dec 2010 - Sept 2013	30	0	30	100%
San Joaquin River at Fremont Ford [1]	Nov 2011 - Feb 2012	4	0	4	100%
San Joaquin River at Hills Ferry Road	Dec 2010 - Sept 2013	15	0	15	100%
San Joaquin River at Las Palmas Avenue near Patterson	Dec 2010 - Sept 2013	32	1	33	97%
San Joaquin River at the Maze Boulevard (Highway 132) Bridge	Dec 2010 - Sept 2013	15	0	15	100%
San Joaquin River at the Airport Way Bridge near Vernalis	Dec 2010 - Sept 2013	15	0	15	100%
Total After Compliance (Dec 2010 – Sept 2013)		**144**	**1**	**145**	**99%**
Prior to Compliance Date (Dec. 1, 2010) [2]					
San Joaquin River at Sack Dam	Jul 2004 - Nov 2010	37	3	40	93%
San Joaquin River at Highway 165 near Stevinson	Jul 2004 - Nov 2010	82	2	84	98%
San Joaquin River at Hills Ferry Road	Mar 2010 - Oct 2010	4	0	4	100%
San Joaquin River at Las Palmas Avenue near Patterson	Apr 2008 - Nov 2010	28	8	36	78%
San Joaquin River at the Maze Boulevard (Highway 132) Bridge	Mar 2010 - Oct 2010	4	0	4	100%
San Joaquin River at the Airport Way Bridge near Vernalis	Jan 2006 - Aug 2006	32	0	33	97%
Total Before Compliance (Jul 2004 – Nov 2010)		**187**	**13**	**201**	**93%**
Grand Total		**330**	**14**	**345**	**96%**

[1] Compliance monitoring occurred at the San Joaquin River at Fremont Ford site from November 2011 through February 2012 because road construction prevented access to the San Joaquin River at Highway 165 near Stevinson site.
[2] Data before December 2010 are from the Westside Coalition ILRP monitoring program and from the monitoring conducted by the Regional Board to support the development and implementation of the chlorpyrifos and diazinon TMDL in the Lower San Joaquin River (Organophosphate TMDL Monitoring for the San Joaquin River (Region 5) project).

OBJECTIVE 2: DETERMINE COMPLIANCE WITH ESTABLISHED LOAD ALLOCATIONS FOR DIAZINON AND CHLORPYRIFOS.

The ESJWQC and Westside Coalitions are required to assess compliance with load allocations for agricultural discharges to the SJR for each of the five subareas (Table 5 and Figure 5). The two Coalitions each characterize and assess water quality within their respective regions through their own strategies of representative monitoring (described in the ESJWQC MRPP and Westside Coalition MRP). The following sections include a review of monitoring results from the Coalition's respective tributary monitoring during the 2013 WY. The formula in Figure 1 is applied to tributary monitoring results to assess compliance with chlorpyrifos and diazinon load allocations.

ESJWQC Load Allocation Compliance

The ESJWQC conducted 106 monitoring events for chlorpyrifos and diazinon in 19 tributaries from October 2012 through September 2013 (Table 19). On April 17, 2012, the ESJWQC received approval to reduce monitoring from April through December 2012 including the temporary suspension of conducting Core and Management Plan Monitoring (MPM) (with the exception of Bear Creek @ Kibby Rd) and reduce monitoring constituents at Assessment Monitoring sites (ESJWQC 2013 AMR, Pages 34-38). The Coalition resumed monitoring in January 2013 according to the May 6, 2011 approval.

Table 19. The ESJWQC tributary monitoring schedule for chlorpyrifos (C) and diazinon (D) during the 2013 WY.

Subarea	Tributary Station Name	Monitoring Type and Year	10/9/2012	11/13/2012	12/3/2012	1/8/2013	2/12/2013	2/20/2013	3/12/2013	4/2/2013	4/9/2013	5/14/2013	6/11/2013	7/9/2013	8/13/2013	9/10/2013
Bear Creek, Fresno-chowchilla	Berenda Slough along Ave 18 1/2	A12, MPM13	C,D	C,D	C,D						C			C		C
	Black Rascal Creek @ Yosemite Rd	MPM13										C		C	C	C
	Cottonwood Creek @ Rd 20	MPM13				C	C									
	Deadman Creek (Dutchman) @ Gurr Rd	MPM13							C		C				C	C
	Deadman Creek @ Hwy 59	A12, MPM13	C,D	C,D	C,D						C				C	C
	Dry Creek @ Rd 18	A13, MPM13				C,D	C,D	C,D	C,D	C,D		C,D	C,D	C,D	C,D	C,D
	Howard Lateral @ Hwy 140	MPM13											C			
	Livingston Drain @ Robin Ave	MPM13				C							C	C	C	
	McCoy Lateral @ Hwy 140	A12	C,D	C,D	C,D											
	Miles Creek @ Reilly Rd	A13, MPM13				C,D	C,D	C,D	C,D	C,D		C,D	C,D	C,D	C,D	C,D
Stanislaus River, North Stanislaus	Mootz Drain downstream of Langworth Pond	A13								C,D		C,D	C,D	C,D	C,D	C,D
	Rodden Creek @ Rodden Rd	A12	C,D	C,D	C,D											
Stevinson	Unnamed Drain @ Hwy 140	A13				C,D	C,D	C,D	C,D	C,D		C,D	C,D	C,D	C,D	C,D
Tuolumne River, Northeast Bank	Dry Creek @ Wellsford Rd	MPM13												C	C	C
	Lateral 2 1/2 near Keyes Rd	MPM13									C			C		
Turlock, Merced	Highline Canal @ Lombardy Rd	A12, MPM13	C,D	C,D	C,D	C			C					C	C	
	Levee Drain @ Carpenter Rd	A12, A13	C,D	C,D	C,D	C,D	C,D	C,D	C,D	C,D		C,D	C,D	C,D	C,D	C,D
	Merced River @ Santa Fe	MPM13				C								C		
	Mustang Creek @ East Ave	A13				C,D	C,D	C,D	C,D	C,D		C,D	C,D	C,D	C,D	C,D

A12- Assessment Monitoring for constituent during 2012 (October—December)

A13- Assessment Monitoring for constituent during 2013 (January—September)

MPM13-Management Plan Monitoring for constituent during 2013 (during months of past exceedances)

In total, 104 of the 106 tributary monitoring events during the 2013 WY were in of compliance with load allocation. There were two exceedances of WQTLs during ESJWQC tributary monitoring (Table 20): one of chlorpyrifos (Dry Creek @ Wellsford Rd in September) and one of diazinon (Miles Creek @ Reilly Rd - FD in February). To identify the sources contributing to the exceedances of the WQOs for chlorpyrifos and diazinon in these samples, the PUR database was queried for applications of the constituents four weeks prior to each exceedance in the associated subwatershed (Table 21).

Table 20. Chlorpyrifos and diazinon load allocation calculations for Tributary sites in the ESJWQC out of compliance during the 2013 WY.

SJR Subarea	Station Name	Sample Date	Chlorpyrifos	Diazinon	Load	Load Allocation Compliance
Tuolumne River, Northeast Bank	Dry Creek @ Wellsford Rd	9/10/2013	0.14	NT	9.33	Out of compliance
Bear Creek, Fresno-Chowchilla	Miles Creek @ Reilly Rd (FD)	2/20/2013	<0.0026	0.18	1.8	Out of compliance

FD – Field duplicate
NT – Not tested

Table 21. Chlorpyrifos applications made four weeks prior in subwatersheds with chlorpyrifos exceedances.

Monitoring event	Tributary Station Name	Commodity	Number of Applications	Active Ingredient Applied (lbs)	Acres Treated
9/10/2013	Dry Creek @ Wellsford Rd	Corn	3	92	115
		Walnut	8	188	99

The concentration of chlorpyrifos in a sample collected from Dry Creek @ Wellsford Rd on September 10, 2013 was above the 0.015 µg/L WQTL (0.14 µg/L; Table 20). The PUR data associated with the September exceedance indicate that from August 24, 2013 through September 10, 2013 a total of 11 applications (Drexel, Lorsban and Warhawk) ranging between 0.31 and 80.80 lbs active ingredient (AI) were applied. A total of 280 lbs of chlorpyrifos was applied aerially and by ground across 214 acres of corn and walnuts (Table 21)

The FD sample collected during the first storm event from Miles Creek @ Reilly Rd on February 20, 2013 had an exceedance of the 0.10 µg/L WQTL for diazinon (0.18 µg/L; Table 20). Diazinon was detected in the FD sample only; the environmental sample result was non-detect. No toxicity was associated with this sample. This is the first exceedance of the WQTL for diazinon to occur in the Miles Creek @ Reilly Rd site subwatershed. There were no applications of diazinon within this subwatershed within one month of the exceedance. However, PUR data are considered preliminary and additional reporting may still occur. A substantial amount of rainfall occurred in the ESJWQC region from late January through February 19, 2013 and may have increased storm runoff within this subwatershed.

The calculation of load allocations for all tributaries sampled during the 2013 WY is included in Appendix IV (Tables IV-2 through IV-5). Note that values in the Appendix include only environmental samples collected. Samples not collected because the waterbody was dry (22 events), and field duplicates, including the single diazinon exceedance, are not included in the Appendix. Table 20 includes the calculated load allocations for both exceedances including the FD.

Overall, 96% of samples collected from ESJWQC tributaries have been compliant with load allocations since the inception of TMDL monitoring in January 2010. During the 2013 WY, 98% of the samples were compliant (Table 22). None of the tributary exceedances in the ESJWQC tributaries affected load compliance in the SJR.

Table 22. Tally of ESJWQC chlorpyrifos and diazinon TMDL load allocation compliance for each subarea since inception of San Joaquin River monitoring (January 2010 through September 2013).

Subarea	Water Year	In Compliance	Out of compliance	Samples Collected	Percent in Compliance
Bear Creek, Fresno-Chowchilla	2010	19	5	24	79%
	2011	56	3	59	95%
	2012	34	0	34	100%
	2013	49	1	50	98%
Stanislaus River, North Stanislaus	2010	9	0	9	100%
	2011	10	0	10	100%
	2012	12	0	12	100%
	2013	9	0	9	100%
Stevinson, Grassland	2013	10	0	10	100%
Tuolumne River, Northeast Bank	2010	7	3	10	70%
	2011	12	0	12	100%
	2012	3	0	3	100%
	2013	4	1	5	80%
Turlock, Merced	2010	12	1	13	92%
	2011	34	0	34	100%
	2012	29	0	29	100%
	2013	32	0	32	100%
	Total for 2010	**47**	**9**	**56**	**84%**
	Total for 2011	**112**	**3**	**115**	**97%**
	Total for 2012	**78**	**0**	**78**	**100%**
	Total for 2013	**104**	**2**	**106**	**98%**
	Grand total 2010-2013	**342**	**14**	**355**	**96%**

Westside Coalition Load Allocation Compliance

The Westside Coalition collected monthly samples from tributary sites flowing to the SJR from October 2012 through September 2013 in accordance with its MRP. The 2013 WY was a critically dry year, and there were few significant storm events during the non-irrigation season. The Westside Coalition collected a storm sample from tributary sites on January 8, 2013. Table 23 includes the monitoring schedule for the SJR and tributary sites monitored by the Westside Coalition.

Table 23. Westside Coalition tributary monitoring schedule during the 2013 WY.

Monitoring Site	Non-Irrigation Season					Irrigation Season						Non-Irr.
	Event 96	Event 97	Event 98	Event R13	Event 99	Event 100	Event 101	Event 102	Event 103	Event 104	Event 105	Event 106
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept
Discharge Sites												
Hospital Cr at River Road	N	N	N	P,NF	N	P,NF	P,NF	P	P	P	P,NF	N
Ingram Cr at River Road	N	N,NF	N,NF	P	N,NF	P	P	P	P	P	P	N
Westley Wasteway near Cox Road	N	N,NF	N	P,NF	N	P	P	P	P	P	P	N
Del Puerto Cr near Cox Road	N	N	N,NF	P,NF	N,NF	P	P	P	P	P	P	N
Del Puerto Cr at Hwy 33	N	N	N	P,NF	N	P,NF	P,NF	P,NF	P,NF	P,NF	P,NF	N
Ramona Lake near Fig Avenue	N	N, NF	N	P,NF	N	P	P	P	P	P	P	N
Marshall Road Drain near River Road	N	N,NF	N,NF	P,NF	N,NF	P	P,NF	P	P	P	P	N
Orestimba Cr at River Road	N,NF	N,NF	N	P	N,NF	P,NF	P,NF	P,NF	P,NF	P,NF	P,NF	P,NF
Orestimba Cr at Hwy 33	N	N	N	P	N	P	P	P	P	P	P	NA
Newman Wasteway near Hills Ferry Road	N	N	N	P	N	P	P	P	P	P	P	NA
Mud Slough u/s San Luis Drain	P	P	P	P	P	P	P	P	P	P	P	P
Salt Slough at Lander Avenue	P	P	P	P	P	P	P	P	P	P	P	P
Salt Slough at Sand Dam	N	N	N	P	N	P	P	P	P	P	P	N
Los Banos Creek at Highway 140	P	P	P	P	P	P	P	P	P	P	P	P
Los Banos Creek at China Camp Road	N	N	N	P	N,NF	P	P	P	P	P	P	N
Turner Slough near Edminster Road	N,NF	N,NF	N,NF	P	NF	P	P	P	P	P	P	N
Blewett Drain near Highway 132	N	N,NF	N,NF	P,NF	N,NF	P	P,NF	P,NF	P	P	P	N
Poso Slough at Indiana Avenue	N	N,NF	N,NF	P	N	P	P	P	P	P	P	N
Source Water Sites												
Delta Mendota Canal at Del Puerto WD	P	P	P	NA[1]	P	P	P	P	P	P	P	P

N -- Sample not tested for pesticides
NF -- Not sampled due to lack of flow
NA -- Not Sampled due to lack of safe access
P -- Sample tested for chlorpyrifos & diazinon if adequate water is present.
R13--Rain event 13 (Jan 2013) sample collection was aborted during collection. Two samples were not collected.

Although there was only one exceedance of the chlorpyrifos WQTL and no exceedances of the diazinon WQTL in the SJR samples, chlorpyrifos was detected in twelve samples (over six different monitoring events) and diazinon was detected in ten samples (over two monitoring events). All detections of chlorpyrifos and diazinon were measured in excess of the load criteria. Table 24 shows the sites and dates where chlorpyrifos and/or diazinon were detected. The Westside Coalition's November 2012 SAMR discusses these detections, as well as other pesticide detections, in greater detail. A tabulation of load allocations for all tributary results is included in Appendix IV.

Table 25 provides load allocations for Westside Coalition tributaries for each subarea. Overall, the percentage of load allocations in compliance during the 2013 WY (October 2012 – September 2013; 87%) was greater compared to 2010 (January – September; 79%) when implementation of the TMDL program began.

Table 24. Chlorpyrifos and diazinon load allocation calculations for tributary sites in the Westside Coalition out of compliance during the 2013 WY.

	Main Stem Monitoring Point	Tributary Site	Sample Date	Sample Event	Flow (cfs)	Chlorpyrifos (µg/L)	Diazinon (µg/L)	Load	Load Allocation Compliance
Greater Orestimba	San Joaquin River at Las Palmas Avenue near Patterson	Marshall Road Drain near River Road	5/14/2013	102	2	<0.0026	2.9	29.00	Out of compliance
		Orestimba Creek at Hwy 33	5/14/2013	102	0	<0.0026	1.3	13.00	Out of compliance
		Ramona Lake near Fig Avenue	5/14/2013	102	0	<0.0026	0.12	1.2	Out of Compliance
Stevinson, Grassland	San Joaquin River at Hills Ferry Road	Los Banos Creek at China Camp Road	6/11/2013	103	0	0.088	<0.004	5.87	Out of compliance
		Newman Wasteway near Hills Ferry Road	5/14/2013	102	789	<0.0026	0.12	1.2	Out of compliance
		Poso Slough at Indiana Avenue	3/12/2013	100	31.5	0.13	<0.004	8.67	Out of compliance
		Poso Slough at Indiana Avenue	5/14/2013	102	25	0.26	<0.004	17.33	Out of compliance
		Poso Slough at Indiana Avenue	6/11/2013	103	23.4	0.050	<0.004	3.33	Out of compliance
		Salt Slough at Sand Dam	4/9/2013	101	59.7	0.072	<0.004	4.80	Out of compliance
Westside Creek	San Joaquin River at the Maze Boulevard (Highway 132) Bridge	Blewett Drain at Highway 132	7/9/2013	104	5.4	0.026	<0.004	1.73	Out of compliance
		Del Puerto Creek near Cox Road	5/14/2013	102	14.5	<0.0026	0.066	0.66	In compliance
		Hospital Creek at River Road	5/14/2013	102	0.2	0.27	0.25	20.50	Out of compliance
		Hospital Creek at River Road	6/11/2013	103	0.5	0.055	0.22	5.87	Out of compliance
		Ingram Creek at River Road	1/8/2013	R13	0	0.21	<0.004	14.00	Out of compliance
		Ingram Creek at River Road	5/14/2013	102	11.5	0.27	0.55	23.5	Out of compliance
		Ingram Creek at River Road	6/11/2013	103	12.2	<0.0026	1.1	11	Out of compliance
		Westley Wasteway near Cox Road	5/14/2013	102	0	<0.0026	0.072	0.72	In compliance

Table 25. Tally of Westside Coalition chlorpyrifos and diazinon TMDL load allocation compliance per each of the subareas.

Subarea	Water Year	In Compliance	Out of compliance	Samples Collected	Percent in Compliance
Greater Orestimba	2010	18	12	30	60%
	2011	26	7	33	79%
	2012	30	1	31	96%
	2013	16	3	19	84%
Stevinson, Grassland	2010	70	4	74	95%
	2011	87	3	90	97%
	2012	87	4	91	96%
	2013	65	6	71	92%
Westside Creeks	2010	18	13	31	58%
	2011	30	6	36	83%
	2012	36	5	41	88%
	2013	19	6	25	76%
	2010 WY[1] Total	**106**	**29**	**135**	**79%**
	2011 WY[1] Total	**143**	**16**	**159**	**90%**
	2012 WY[1] Total	**153**	**10**	**163**	**94%**
	2013 WY[1] Total	**100**	**15**	**115**	**87%**
	Grand Total	**249**	**45**	**294**	**85%**

[1]Water Year is from October through September. Data in the table represents complete data sets for 2010, 2011, and 2012 WYs.

The PUR data listed in Table 26 have been provided by the county agricultural commissioners and is summarized for the sites listed in Table 24. The PUR data summary is organized by site and material AI, and includes the number of treatments and total acres treated of each commodity.

Table 26. Chlorpyrifos and diazinon applications made four weeks prior in subwatersheds with exceedances in the Westside Coalition region.

Only listed applications were shown based on available PUR data.

Tributary Name	Material	Application Month	Commodity	Number of Applications*	Acres Treated*
Del Puerto Creek	Diazinon	March	Tomatoes	1	28
	Diazinon	April	Tomatoes	3	277
Ramona Lake	Diazinon	April	Tomatoes	2	40
Marshall Road Drain	Diazinon	April	Tomatoes	2	360
Orestimba Creek	Diazinon	April	Tomatoes	4	565
	Diazinon	May	Tomatoes	1	80
Newman Wasteway	Diazinon	April	Peppers	1	22
	Diazinon	May	Peppers	2	190
Salt Slough @ Sand Dam	Chlorpyrifos	March	Alfalfa	11	589
Blewett Drain	Chlorpyrifos	June	Walnuts	4	455
Hospital Creek	Chlorpyrifos	March	Alfalfa	1	65
	Diazinon	April	Tomatoes	1	80
	Diazinon	May	Tomatoes	1	95
	Chlorpyrifos	June	Walnuts	1	78
Ingram Creek	Chlorpyrifos	March	Alfalfa	1	65
	Diazinon	April	Cherries	7	110
	Diazinon	April	Tomatoes	4	360
	Diazinon	May	Tomatoes	3	120
	Diazinon	June	Beans	1	62
Westley Wasteway	Diazinon	April	Tomatoes	1	50

*Data is provisional and subject to change.

Available PUR data identified 29 separate pesticide applications within subwatersheds where either chlorpyrifos or diazinon were detected during sampling. For five of the detections listed in Table 26, no use for the detected material was reported within eight weeks of the detection date.

Conversations with growers and pest control advisers indicated that insect pressures in the 2013 WY were much higher than normal, resulting in a greater pesticide applications compared to previous years.

OBJECTIVE 3: DETERMINE DEGREE OF IMPLEMENTATION OF MANAGEMENT PRACTICES AND STRATEGIES TO REDUCE OFF-SITE MOVEMENT OF DIAZINON AND CHLORPYRIFOS

Each Coalition developed their own management practice tracking and evaluation strategies suitable for their regions and members (ESJWQC Management Plan submitted September 30, 2008 and Westside Coalition Management Plan and Focused Management Plan submitted October 23, 2008). The Coalitions review the results of their respective strategies to determine the degree of implementation of management practices and strategies to reduce the offsite movement of chlorpyrifos and diazinon.

ESJWQC Implementation of Management Practices to Reduce Off Site Movement of Diazinon and Chlorpyrifos

After one exceedance of the WQO for chlorpyrifos or diazinon, individually or in combination, at a tributary monitoring site, the ESJWQC must establish a management plan for the site subwatershed. To allow for source identification, focused outreach, and evaluation, the ESJWQC prioritizes site subwatersheds based on the number, frequency, and magnitude of chlorpyrifos and diazinon exceedances, among other factors (2013 MPUR, Pages 23-24). When a site subwatershed rotates to high priority, the ESJWQC develops a three year process designed to document current management practices (Year 1), encourage and document the implementation of new management practices (Years 1 and 2), and evaluate the effectiveness of outreach in the site subwatershed via MPM for management plan constituents (Years 1-3). Members with the greatest potential to influence water quality are targeted. These are growers with the potential for direct drainage and growers with past applications of management plan constituents (i.e. chlorpyrifos or diazinon). The focused outreach and management practice documentation rotates to additional site subwatersheds annually. Current high priority site subwatersheds include:

First Priority Site Subwatersheds (2008 – 2010)

- Dry Creek @ Wellsford Rd
- Duck Slough @ Hwy 99
- Prairie Flower Drain @ Crows Landing Rd

Second Priority Site Subwatersheds (2010 – 2012)

- Bear Creek @ Kibby Rd
- Cottonwood Creek @ Rd 20
- Duck Slough @ Gurr Rd
- Highline Canal @ Hwy 99

Third Priority Site Subwatersheds (2011 – 2013)

- Berenda Slough along Ave 18 ½
- Dry Creek @ Rd 18
- Lateral 2 ½ near Keyes Rd
- Livingston Drain @ Robin Ave

Fourth Priority Site Subwatersheds (2012 – 2014)

- Black Rascal Creek @ Yosemite Rd
- Deadman Creek (Dutchman) @ Gurr Rd
- Deadman Creek @ Hwy 59
- Hilmar Drain @ Central Ave

Fifth Priority Site Subwatersheds (2013 – 2015)

- Hatch Drain @ Tuolumne Rd
- Highline Canal @ Lombardy Rd
- Merced River @ Santa Fe
- Miles Creek @ Reilly Rd

The ESJWQC has completed its focused outreach strategy in the first through fourth priority site subwatersheds. The ESJWQC has documented all current and newly implemented management practices for targeted member parcels in the first through fourth priority site subwatersheds. Dry Creek @ Wellsford Rd is within the first set of high priority subwatersheds and completed focused outreach in 2010. The ESJWQC established a management plan for chlorpyrifos in the Dry Creek @ Wellsford Rd site subwatershed in 2006. The exceedance of the chlorpyrifos WQTL in September was the first exceedance since 2010 at this site (results were reported in the ESJWQC 2011 and 2012 MPURs). Based on PUR data, applications of chlorpyrifos were made on the date the sample was collected. Parcels next to the waterbody have a higher likelihood of having direct drainage and a higher potential for spray drift to end up in the water column. Chlorpyrifos applications to corn were made to a non-member parcel located within a mile of the creek and along a canal/lateral that drains directly to Dry Creek and likely caused the exceedance. As of 2010, members within this subwatershed have been implementing the following practices: shutting off outside nozzles when spraying outer rows next to sensitive sites, constructing drainage basins/sediment ponds, maintaining filter strips at least 10 feet wide around field perimeters, allowing grass to grow in the centers of orchard rows, using recirculation/tailwater return systems, and using less water during surface irrigation for operations with no irrigation drainage.

Focused outreach is ongoing in the fifth priority site subwatersheds; current management practices (2013) have been documented for the fifth priority site subwatersheds. The ESJWQC is in the process of conducting follow-up contacts to document newly implemented practices (2013-2014). Miles Creek @ Reilly Rd is one of the fifth priority site subwatersheds and targeted growers received focused outreach in 2013 through individual meetings. The exceedance of the diazinon WQTL in February was the first exceedance since monitoring began at this site in 2007, and occurred only in the FD. There were no applications within a month of this exceedance although it is possible for additional use to be reported (PUR data are considered preliminary). At this time, the ESJWQC does not know the source of the diazinon exceedance within the Miles Creek subwatershed. Current management practices within the Miles Creek subwatershed include: laser leveled fields, recirculation tailwater return, drainage basins, microirrigation, moisture levels, berms between field and waterway, settling pond, grass row centers, vegetated filter strips, adjust spray nozzles, turn off outside nozzles, spray next to waterbody when wind is blowing away, use air blast, nozzles with largest effective droplet size, and no dormant sprays.

The ESJWQC outreach activities and actions to address water quality exceedances during the 2013 WY are documented in the ESJWQC 2013 AMR and the 2014 Annual Report. All ESJWQC outreach activities that occurred in 2013 related to the management practice tracking strategy are documented in the 2014 Annual Report.

A major goal of ESJWQC outreach is to help growers eliminate the offsite movement of agricultural constituents. The ESJWQC identified five categories of management practices that are effective in reducing the offsite movement of chlorpyrifos and diazinon:

- Irrigation Water Management
- Storm Drainage Management
- Erosion and Sediment Management
- Pest Management
- Dormant Spray Management

Targeted growers in the first through fifth priority site subwatersheds indicated they currently implement management practices within each of the above categories. Several growers in the first through fourth priority subwatersheds implemented new management practices in each of these categories following focused ESJWQC outreach. Figure 8 includes the acreage associated with management practices implemented before ESJWQC outreach (currently implemented) and after ESJWQC outreach (newly implemented) in the first through fourth priority subwatersheds per each of the five categories). The acreage represented in Figure 8 is associated with at least one management practice per each category, but acreage may have multiple practices implemented within a category (acreage is only counted once per each category). The majority of targeted acreage in the first through fourth priority subwatersheds have at least one management practice designed to address erosion and sediment management, irrigation management, and pest management. The newly implemented practices are focused on irrigation management, pest management, and storm drainage management.

Within each of the five categories, growers implemented various management practices (Table 27). Pest management practices such as adjusting spray nozzles to match crop canopy profile and using nozzles that provide the largest effective droplet size to minimize drift are utilized by almost every targeted grower. Other common practices include laser leveling fields and planting or allowing vegetation to grow along ditches (Table 27).

Figure 8. Acreage with one or more implemented management practice per each category in the ESJWQC first, second, third, and fourth priority subwatersheds.

Targeted acreage associated with grower displayed if one or more practice(s) are implemented per category. Several practices serve multiple purposes and fall into more than one category, but practices are counted only once with their primary category.

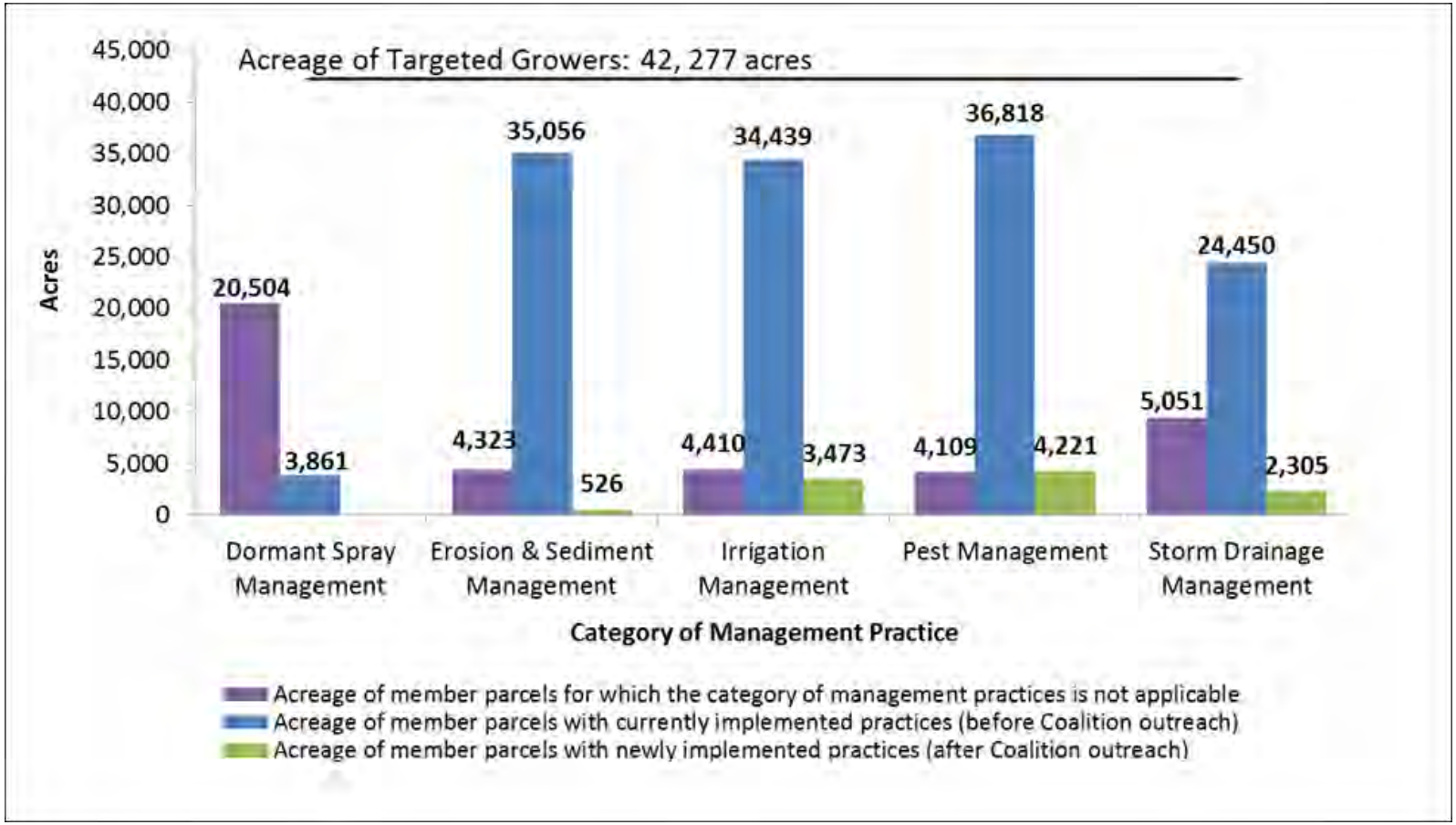


Table 27. Current and newly implemented management practices designed to reduce offsite movement of chlorpyrifos and diazinon in the ESJWQC first, second, third, and fourth priority subwatersheds listed by TMDL subarea.

Category	Management Practice	Bear Creek, Fresno-Chowchilla		Tuolumne River, Northeast Bank		Turlock, Merced		Total	
		Growers	Acres	Growers	Acres	Growers	Acres	Growers	Acres
Dormant Spray Management	Check weather conditions prior to spraying (i.e. storm status)	13	5460	4	346	2	181	19	5,987
	Do not apply dormant spray when moisture is at field capacity	7	3105	3	266	2	181	12	3,552
	Maintain setback zones	13	5460	3	131	2	181	18	5,772
	Vegetation cover and/or disked	16	5565	10	712	3	201	29	6,478
Erosion & Sediment Management	Constructed wetlands	1	87	1	2,450			2	2,537
	Grass Row Centers (Orchards, Vineyards)	93	23193	38	6,510	6	247	137	29,950
	Maintain vegetated filter strips around field perimeter at least 10' wide	94	19429	24	6,227	16	1505	134	27,161
	Riparian vegetation / fences prevents livestock access to water	6	640	2	53			8	693
	Vegetation is planted along or allowed to grow along ditches	75	19933	24	6,532	20	1851	119	28,316
Irrigation Management	Determine Irrigation Schedule by Actual Moisture Levels in Soil/Crop Needs	155	35216	23	5,717	11	534	189	41,467
	Drainage basins (sediment ponds)	32	11466	5	3,203	3	227	40	14,896
	Drip irrigation, other	6	408	1	77			7	485
	Laser leveled fields	103	21783	39	6,743	20	1710	162	30,236
	Microirrigation	96	26705	25	6,721	4	226	125	33,652
	Polyacrylamide (PAM)	1	15	1	2,450	3	227	5	2,692
	Recirculation - Tailwater return system	46	13115	7	4,046	7	517	60	17,678
	Reduce Amount of Water Used in Surface Irrigation	12	1903	1	162	4	468	17	2,533
Pest Management	Adjust spray nozzles to match crop canopy profile	124	28851	47	8,016	21	1404	192	38,271
	Calibrate spray equipment prior to each application	138	32108	68	9,796	21	1587	227	43,491
	Shut off outside nozzles when spraying outer rows next to sensitive sites	119	26783	45	7,885	20	1668	184	36,336
	Spray areas close to waterbodies when the wind is blowing away from them	129	29354	46	7,848	26	2112	201	39,314
	Use air blast applications when wind is between 3-10 mph and upwind of a sensitive site	88	17627	30	5,895	9	413	127	23,935
	Use electronic controlled sprayer nozzles	9	1981	3	2,555	6	362	18	4,898
	Use nozzles that provide largest effective droplet size to minimize drift	130	30088	46	7,918	26	2112	202	40,118
Storm Drainage	Berms Between Field & Waterway	12	1566			2	316	14	1,882
	Device Controls Timing of Pump/Drain into Waterway	22	6389	2	3,147	6	828	30	10,364
	No Storm Drainage	6	1214			1	139	7	1,353
	Recirculation - Tailwater return system	29	9507	1	26	2	278	32	9,811
	Settling Pond	25	9640	3	2,499	3	348	31	12,487

The ESJWQC initiated focused outreach in sixth priority subwatersheds through mailings in 2013, and individual meetings are scheduled to occur with growers during 2014 (Ash Slough @ Ave 21, Mustang Creek @ East Ave, Westport Drain @ Vivian Rd) to document currently implemented practices. These data will be assessed in the ESJWQC 2015 Annual Report.

Westside Coalition Implementation of Management Practices to Reduce Off Site Movement of Diazinon and Chlorpyrifos

In 2008, the Westside Coalition adopted a Management Plan to address water quality exceedances detected by the monitoring order. Although the Management Plan outlined area specific measures based on the exceedances in that region, identified management practices for pesticides (including chlorpyrifos and diazinon) are uniform for the entire Westside Coalition. These measures include:

- Construct sediment basins to intercept tailwater.
- Install high-efficiency irrigation systems such as sprinkler or drip irrigation, tailwater recirculation, gated pipes, shorter runs, etc., where warranted by the crops that are grown.
- Implement additional use of polyacrylamide (PAM) to address sedimentation discharge.
- Reduce use of pesticides, or incorporate use of pesticides that are less likely to be transported to the State waterways, or which breakdown quickly and are less likely to impact water quality.
- Calibrate ground spray rigs utilized on farmed acres to address possible overspray.
- Address potential aerial overspray by identifying the sensitive regions for all aerial applicators, or elimination of this as an acceptable application procedure.
- Increase size of vegetated buffer zones along the perimeters waterways.

As a mechanism to encourage and track the implementation of management practices, the Westside Coalition implemented an aggressive outreach program that included field meetings with individual growers, workshops, sponsorship of integrated pest management programs (such as the Sustainable Cotton Program) and a detailed management practice inventory survey to determine what management practices have already been implemented. A status update of management plan implementation is included in Attachment 6 of each SAMR. Table 28 summarizes the management practice inventory data for the Westside Coalition region. In addition to these actions, a staff person of the Westside Coalition travels through the Coalition area on a weekly basis to review irrigation activities, drainage conditions, and meet with growers to review management practice implementation. All of these management practices are implemented at the farm-level and driven by a variety of factors, including water supply, crop values, soil quality, and regulatory pressures.

In response to the diazinon and chlorpyrifos exceedances in March and May, the Westside Coalition mailed out newsletters to growers within the entire Coalition. The newsletter emphasized importance of implementing management practices to prevent pesticide discharge.

Table 28. Management practice inventory data for subwatersheds in the Westside Coalition region.

	Salt Slough (partial) 2011/12		Westley Wasteway 2010		Del Puerto Creek 2010		Orestimba Creek 2010		Hospital Creek 2009		Ingram Creek 2009	
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Survey Area	64,99	100%	5,248		9,195		12,85		7,142		5,779	
Surveys Collected	874	100%	70	100%	274	100%	160	100%		100%		100%
Irrigated	63,97	98%	4,565	87%	7,926	86%	11,71	91%	5,193	69%	5,526	96%
Furrow/Flood (% Irrig. Ac.)	49,57	77%	1,489	33%	3,210	41%	4,491	38%	1,678	32%	4,599	80%
Drip/Micro/Sprinkler (% Irrig. Ac.)	14,40	23%	2,891	63%	3,952	50%	5,821	50%	3,515	68%	927	16%
Fallow/Non Irrigated (% Irrig. Ac.)	1,056	2%	0	0%	230	3%	1,354	12%	1,949	38%	3	<1%
Mix of Irrigation Methods (% Irrig. Ac.)	0	0%	185	4%	535	7%	48	0%				
Tree Crops (% Irrig. Ac.)	1,203	1.9%	2,891	63%	4,237	53%	5,481	47%				
Field Crops (% Irrig. Ac.)	62,89	98%	1,670	37%	3,678	46%	5,626	48%				
Open / Other (% Irrig. Ac.)	1,039	1.6%	662	15%	325	4%	847	7%				
Sedimentation Ponds (% Field Crops)	370	0.6%	1,092	65%	3,331	36%	5,019	89%	1,085	14%	935	17%
Tailwater Return System (% Field Crops)	0	0%	150	9%	402	4%	2,154	38%	205	3%	828	15%
Use of PAM (% Irrig. Ac.)	710	1%	3,346	73%	2,955	37%	3,408	29%	488	29%	4,375	95%
Tailwater Leaves Property (% Irrig. Ac.)	58,70	92%	2,234	49%	3,471	44%	4,134	35%	1,473	28%	4,393	76%
Stormwater Leaves Property (% Irrig. Ac.)	57,49	90%	2,517	55%	5,050	64%	6,384	55%	4,118	79%	5,204	90%
Dormant Spray Usage (% Tree Crops)			905	31%	1,147	27%	400	7%	926	12%	22	<1%
Horticultural Oil Usage (% Tree Crops)			905	31%	748	18%	806	15%				

OBJECTIVE 4: DETERMINE DEGREE OF EFFECTIVENESS OF MANAGEMENT PRACTICES AND STRATEGIES TO REDUCE OFF-SITE MOVEMENT OF DIAZINON AND CHLORPYRIFOS

The Coalitions review management practice effectiveness at the subwatershed level within their regions to offer evidence of management practice effectiveness in addition to water quality in the SJR.

ESJWQC Effectiveness of Management Practices to Reduce Off Site Movement of Diazinon and Chlorpyrifos

The ESJWQC uses the results of MPM and Assessment Monitoring to evaluate the effectiveness of current and newly implemented management practices. MPM was temporarily suspended through the end of 2012 with the exception of Bear Creek @ Kibby Rd. Sites scheduled for Assessment Monitoring were monitored for reduced number of constituents that included MPM constituents. Berenda Slough along Ave 18 ½ (third priority) and Deadman Creek @ Hwy 59 (fourth priority) were the only sites within the first through fourth priority subwatersheds scheduled for Assessment Monitoring in 2012, and Dry Creek @ Rd 18 (third priority) was scheduled for Assessment Monitoring January through September 2013 (Table 19). The following evaluation is based on the monitoring results from 2013 WY.

The ESJWQC conducted focused outreach from 2009 through 2013, which resulted in the implementation of several new management practices designed to address the offsite movement of agricultural constituents, including chlorpyrifos and diazinon (Figure 8 and Table 27). Results from MPM during months of past exceedances and monthly Assessment Monitoring indicate focused outreach and implementation of new management practices from 2009 through 2013 coincided with an overall

decrease in chlorpyrifos and diazinon exceedances (Table 29). Prior to focused outreach, there were twelve to thirteen exceedances of the WQTL for chlorpyrifos per year (10-15% of samples collected annually) in the first through fourth priority subwatersheds (Table 29). There have been only three exceedances of the diazinon WQTL since 2006 in the first through fourth priority subwatersheds (< 1% of samples collected, Table 29). The diazinon exceedance the occurred in 2013 is not included in this table since it occurred in samples collected from a site subwatershed that is still undergoing focused outreach and documentation of newly implemented management practices.

Table 29. Count of exceedances and samples collected for chlorpyrifos and diazinon in the ESJWQC first, second, third, and fourth priority site subwatersheds.

Years in the table reflect a calendar year, January through December.

Calendar Year	Chlorpyrifos				Diazinon			
	Count of Exceedances	Count of Samples[1]	% of Exceedances	Lbs Applied[2]	Count of Exceedances	Count of Samples[1]	% of Exceedances	Lbs Applied[2]
2006	12	81	15%	88,930	0	81	0%	4,100
2007	13	114	11%	68,454	1	110	1%	4,274
2008	13	129	10%	41,386	2	120	2%	2,355
2009	3	36	8%	95,087	0	29	0%	1,855
2010	7	41	17%	49,163	0	26	0%	1,148
2011	3	98	3%	40,361	0	85	0%	1,131
2012	0	31	0%	43,080	0	24	0%	410
Jan-Sept 2013	1	35	3%	59,633	0	10	0%	376
All Years	**52**	**565**	**9%**	**486,098**	**3**	**485**	**<1%**	**15,650**

[1] Refers to all samples scheduled for constituent analysis (dry sites are included).
[2] All PUR data are considered preliminary until received from CalPIP; CalPIP data are available through December 2011.
NA – Not Applicable, no samples were collected for the constituent during the year.

On October 15, 2013, the ESJWQC received approval to remove eight specific site/constituent pairs from active management plans in seven site subwatersheds, of those site subwatersheds, two were approved to have chlorpyrifos removed and one was approved to have diazinon removed. The removal of these constituents (including chlorpyrifos and diazinon) from active management plans indicates the effectiveness of management practices implemented by members of the ESJWQC in each of the site subwatersheds.

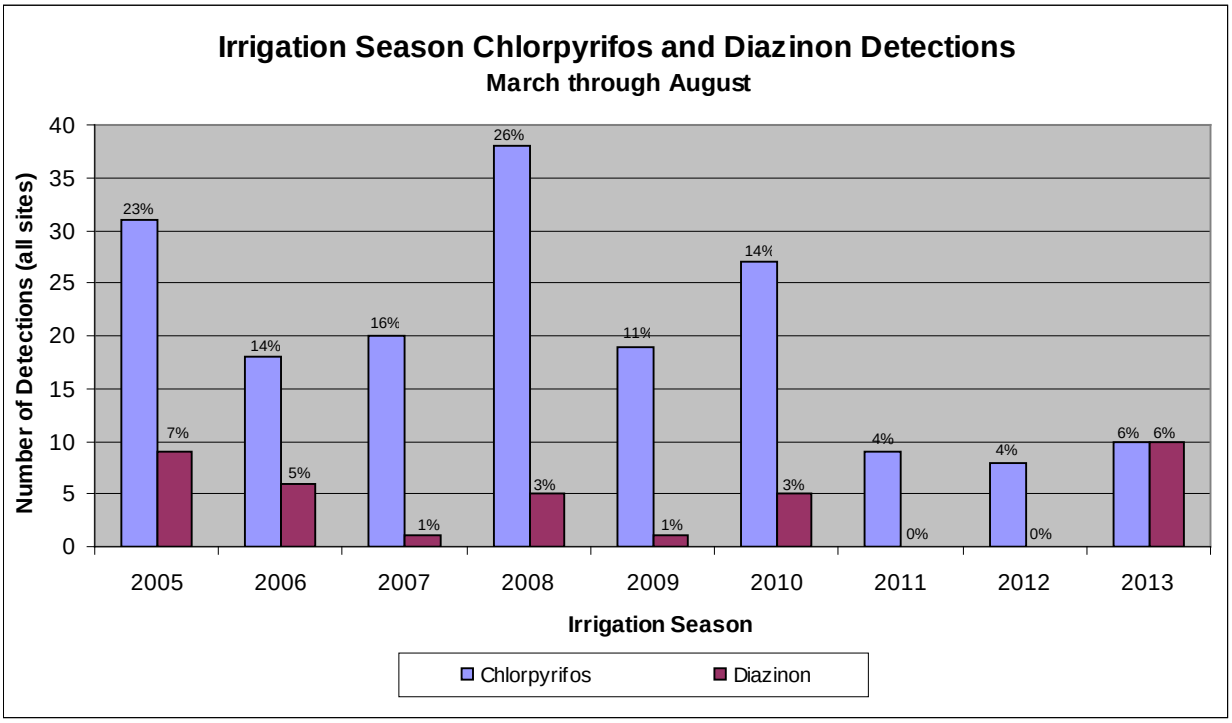
Westside Coalition Effectiveness of Management Practices to Reduce Off Site Movement of Diazinon and Chlorpyrifos

The Westside Coalition continues to struggle with chlorpyrifos exceedances at tributary monitoring sites. Since 2010, the Westside Coalition has mailed more than 300 notices regarding chlorpyrifos and diazinon exceedances and followed up with field visits to review water quality impairments and farming activities with individual growers.

A review of chlorpyrifos and diazinon detections since the beginning of the Westside Coalition's monitoring program provides a promising trend. Figure 9 shows the number of detections of both materials since 2005. Although the number of detections of chlorpyrifos was higher for 2013 when compared to the previous year, they remain substantially lower when compared to monitoring results prior to the implementation of the Westside Coalition Management Plan (2010 and prior). Diazinon

detections for this report period were the highest on record, likely a result of the higher than normal pest pressures.

Figure 9. Count of chlorpyrifos and diazinon detections from 2006 through 2013 in the Westside Coalition tributaries.



OBJECTIVE 5: DETERMINE WHETHER ALTERNATIVES TO DIAZINON AND CHLORPYRIFOS ARE CAUSING SURFACE WATER QUALITY IMPACTS

Overall use of diazinon has declined since 2004 and overall chlorpyrifos use has generally declined since 2008 (Figure 2 and Figure 3). The ESJWQC has assessed PUR data from site subwatersheds through December 2012 because the PUR data are incomplete through 2013. In 2012, the amount of diazinon applied within the SJR watershed decreased approximately 90% compared to 2004 (Figure 10). The use of chlorpyrifos has declined slower than diazinon, but in 2012 chlorpyrifos use was 65% lower than in 2004.

Chlorpyrifos continues to be a widely used pesticide mostly due to the large number of crops for which it is registered, it is relatively low cost, and it effectively controls a variety of pest species even when pest pressures are high. Despite the benefits of chlorpyrifos, growers are aware of the water quality implications and there is evidence suggesting that they have been using alternative products throughout the year to reduce pest pressures and avoid harming beneficial insects.

During grower outreach, ESJWQC and Westside Coalition representatives encourage growers to switch to products that are lower risk alternatives to chlorpyrifos and diazinon, and workshops are offered to

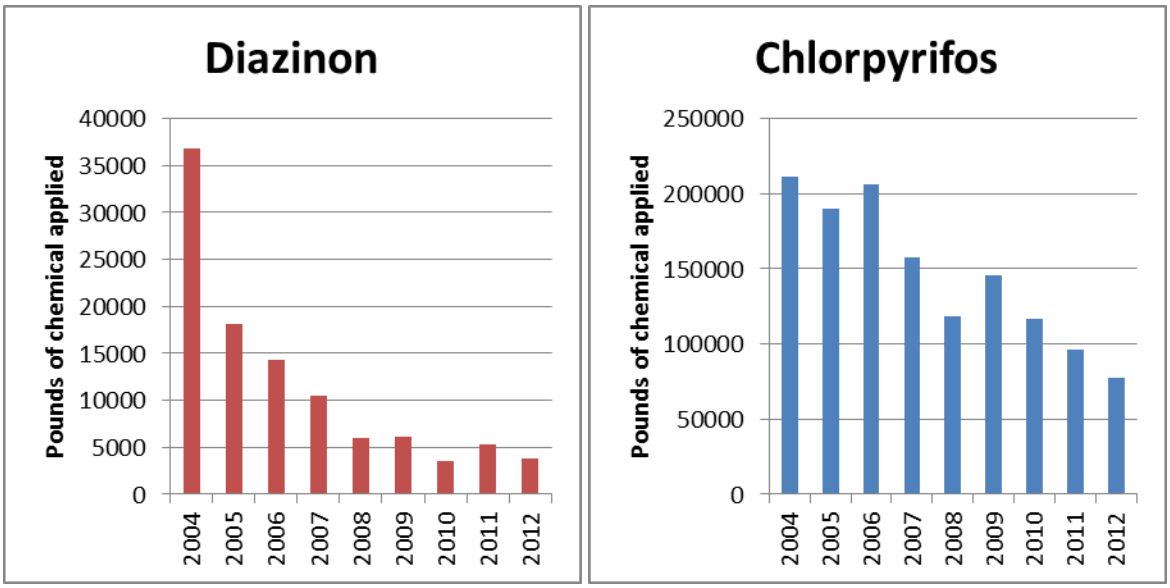
educate growers about the selection of these alternatives. The use of alternatives to chlorpyrifos and diazinon depend on many factors including but not limited to commodity type, pest pressure, cost, and timing of pest control. In addition, pesticide groups have to be rotated to prevent insects from developing resistance. The Coalitions do not monitor for many new pesticides due to a lack of analytical methods and, in many cases, relatively limited use. However, PUR data can provide insight to the products being applied and how use has changed over time.

ESJWQC Assessment of Alternatives to Diazinon and Chlorpyrifos

The pounds of diazinon and chlorpyrifos applied in the ESJWQC region has declined considerably since 2004 (Figure 10). The ESJWQC has not detected diazinon in any samples collected from waterways within the ESJWQC region since February 2009; chlorpyrifos has been detected in samples collected from the water column of tributaries in the ESJWQC region only once since September 2011.

Figure 10. Pounds of diazinon and chlorpyrifos applied in the ESJWQC region from 2004 through 2012 calendar years.

All PUR data are considered preliminary until received from CalPIP; CalPIP data are available through December 2011. The PUR data available from the counties in the ESJWQC region are incomplete through 2013.



To evaluate the use of alternatives to chlorpyrifos and diazinon, the ESJWQC first investigated the commodities in the ESJWQC region with the most use of diazinon or chlorpyrifos. Then the Coalition reviewed the highest priority pests associated with those commodities and the pesticides available to control them. Almonds, peaches, prunes, walnuts, alfalfa, grapes, and corn were identified as the commodities with the most pounds of chlorpyrifos or diazinon applied in the ESJWQC region (Table 30). The highest priority pests are pests that are of major concern for a commodity and that are geographically widespread in the ESJWQC region. The ESJWQC reviewed alternative pesticides and other management strategies (i.e. applications of plant growth regulators) recommended for each high priority pest in each commodity (Table 31).

Table 30. Commodities with the most pounds of chlorpyrifos and diazinon use in the ESJWQC region from 2004 through 2013.

PUR data are incomplete through 2013, with the latest data differing by county from August to November 2013.

Commodity	Diazinon	Chlorpyrifos
Almonds	46596	653362
Peaches	19981	15585
Prunes	18749	2138
Grapes	1389	131630
Walnuts	188	251828
Corn	137	114242
Alfalfa	0	150732

Table 31. High priority pests of the commodities that use the most diazinon and/or chlorpyrifos in the ESJWQC region, with alternative pesticides recommended for those pests.

Commodity	Pest	Pest Appearance	Pesticide Class[1]	Active Ingredient	Common Product Name	Recommended Application Period
Alfalfa	Alfalfa weevil	Feb-Jun	Organophosphate	Chlorpyrifos	Lorsban	Mar-May
				Malathion	Clean crop	Mar-May
				Phosmet	Imidan	Mar-May
			Oxadiazine	Indoxacarb	Steward	Mar-May
			Pyrethroid	Lambda-cyhalothrin	Warrior II	Mar-May
				Cyfluthrin	Baythroid	Mar-May
	Blue and pea aphid	Feb-Jun, Sept	Botanical	Azadirachtin	NA	Mar-May
			Organophosphate	Chlorpyrifos	Lorsban	Mar-May
				Dimethoate	Drexel	Mar-May
			Pyrethroid	Pyrethrin	NA	Mar-May
	Spotted alfalfa aphid	Jun-Sept	Botanical	Azadirachtin	NA	Jun-Aug, Sept- Nov
			Organophosphate	Chlorpyrifos	Lorsban	Jun-Aug, Sept-Nov
				Dimethoate	Drexel	Jun-Nov
			Pyrethroid	Pyrethrin	NA	Jun-Aug
Almond	Navel orange worm	Year round	Avermectin	Emamectin benzoate	Proclaim	Mar-May
			Bacterium	Bacillus thuringiensis	Deliver	Mar-May, Aug
			Diacylhydrazine	Methoxyfenozide	Intrepid	Mar-May, Aug
			Diamide	Chlorantraniliprole	Altacor	Mar-May, Aug
				Flubendiamide	Belt	Mar-May, Aug
			Organophosphate	Chlorpyrifos	Lorsban	Aug
				Diazinon	Gowan	Dec-Feb, May, Jul
				Phosmet	Imidan	Aug
			Pyrethroid	Bifenthrin	Brigade	Aug
				Esfenvalerate	Asana	Aug
				Fenpropathrin	Danitol	Aug
				Lambda-cyhalothrin	Warrior	Aug
			Spinosyn	Spinetoram	Delegate	Mar-May, Aug
				Spinosad	Success	Mar-May, Aug
			Unclassified	Buprofezin	Centaur	Mar-May, Aug
	Peach twig borer	Feb-Oct	Avermectin	Emamectin benzoate	Proclaim	Mar-May
			Bacterium	Bacillus thuringiensis	Deliver	Mar-May
			Benzoylurea	Diflubenzuron	Dimlin	Nov-Mar
			Diacylhydrazine	Methoxyfenozide	Intrepid	Mar-May
			Diamide	Chlorantraniliprole	Altacor	Nov-May
				Flubendiamide	Belt	Mar-May
			Neonicotinoid	Acetamiprid	Assail	Nov-May

Commodity	Pest	Pest Appearance	Pesticide Class[1]	Active Ingredient	Common Product Name	Recommended Application Period
			Organophosphate	Chlorpyrifos	Lorsban	Mar-May
				Diazinon	Gowan	Dec-Feb, May, Jul
			Pyrethroid	Bifenthrin	Brigade	Nov-Feb
				Esfenvalerate	Asana	Nov-Feb
				Lambda-cyhalothrin	Warrior	Nov-Feb
				Cyfluthrin	NA	Nov-Feb
			Spinosyn	Spinetoram	Delegate	Nov-May
				Spinosad	Success	Nov-May
			Unclassified	Buprofezin	Centaur	Mar-May
	San Jose scale	Feb-Aug	Carbamate	Carbaryl	Sevin	Nov-Jan
			Hormone	Pyriproxyfen	Seize	Nov-Jan, Apr
			Organophosphate	Chlorpyrifos	Lorsban	May
				Diazinon	Gowan	Dec-Feb, May, Jul
				Methidathion	Supracide	May
			Unclassified	Buprofezin	Centaur	Apr
Corn	Corn earworm	Jun-Oct	Bacterium	Bacillus thuringiensis	Xentari	Jun-Oct
			Carbamate	Methomyl	Lannate	Jun-Oct
			Organophosphate	Chlorpyrifos	Lorsban	Jun-Oct
			Pyrethroid	Esfenvalerate	Asana	Jun-Oct
				Permethrin	Perm-up	Jun-Oct
			Spinosyn	Spinosad	Success	Jun-Oct
				Spinetoram	NA	Jun-Oct
Grape	Vine mealybug	May-Oct	Carbamate	Methomyl	Lannate	Jun-Nov
			Neonicotinoid	Acetamiprid	Assail	Jun-Aug
				Imidacloprid	Provado	Apr-Aug
			Organophosphate	Chlorpyrifos	Lorsban	Jun-Nov, Feb
				Dimethoate	Dimethogon	Jun-Nov
			Unclassified	Buprofezin	Applaud	Feb, Jun-Aug
Peach	Apricot scale (lecanium)	Feb-Oct	Organophosphate	Diazinon	Diazinon50W	Nov-Jan
	Peach twig borer	May-Sept	Bacterium	Bacillus thuringiensis	Dipel	Mar-May
			Benzoylurea	Diflubenzuron	Dimlin	Jan-May
			Diacylhydrazine	Methoxyfenozide	Intrepid	Jan-May
			Diamide	Chlorantraniliprole	Altacor	Mar-May
				Flubendiamide	Belt	Mar-May
			Organophosphate	Diazinon	Gowan	Jan-Feb
			Pyrethroid	Esfenvalerate	Asana	Jan-Feb
				Permethrin	Perm-up	Jan-Feb
			Spinosyn	Spinetoram	Delegate	Jan-May
				Spinosad	Success	Jan-May
			Unclassified	Buprofezin	NA	Mar-May
	San Jose scale	Apr-Nov	Carbamate	Carbaryl	Sevin	Mar-May
			Hormone	Pyriproxyfen	Seize	Jan-May
			Organophosphate	Diazinon	Gowan	Mar-May
			Unclassified	Buprofezin	NA	Jan-May
Prune	Peach twig borer	Apr-Aug	Bacterium	Bacillus thuringiensis	Dipel	Mar-Apr
			Benzoylurea	Diflubenzuron	NA	Jan-Mar
			Diacylhydrazine	Methoxyfenozide	Intrepid	Mar-Apr
			Organophosphate	Chlorpyrifos	Lorsban	Jan-Feb
				Diazinon	Diazinon50W	Mar-Apr
				Methidathion	Supracide	Jan-Feb

Commodity	Pest	Pest Appearance	Pesticide Class[1]	Active Ingredient	Common Product Name	Recommended Application Period
				Phosmet	Imidan	Jan-Feb, Apr
			Pyrethroid	Esfenvalerate	Asana	Jan-Apr
				Lambda-cyhalothrin	Silencer	Jan-Apr
			Spinosyn	Spinosad	Success	Jan-Apr
	San Jose scale	Apr-Sept	Carbamate	Carbaryl	NA	Nov-Feb
			Hormone	Pyriproxyfen	Seize	Nov-Feb
			Organophosphate	Chlorpyrifos	Lorsban	Nov-Feb
				Diazinon	Diazinon50W	Nov-Feb
				Methidathion	Supracide	Nov-Feb
Walnut	Codling moth	May-Nov	Avermectin	Emamectin benzoate	Proclaim	Mar-May, Aug, Oct
			Benzoylurea	Diflubenzuron	Dimlin	Mar-May, Aug, Oct
			Carbamate	Carbaryl	Sevin	Mar-May, Aug, Oct
			Diacylhydrazine	Methoxyfenozide	Intrepid	Mar-May, Aug, Oct
			Diamide	Chlorantraniliprole	Altacor	Mar-May, Aug, Oct
				Flubendiamide	Belt	Mar-May, Aug, Oct
			Organophosphate	Chlorpyrifos	Lorsban	Mar-May, Aug, Oct
				Phosmet	Imidan	Mar-May, Aug, Oct
			Pyrethroid	Bifenthrin	Brigade	Mar-May, Aug, Oct
				Cyfluthrin	Leverage	Mar-May, Aug, Oct
				Esfenvalerate	Asana	Mar-May, Aug, Oct
				Lambda-cyhalothrin	Warrior II	Mar-May, Aug, Oct
				Permethrin	Perm-up	Mar-May, Aug, Oct
			Spinosyn	Spinetoram	Delgate	Mar-May, Aug, Oct
				Spinosad	Naturalyte	Mar-May, Aug, Oct
	Walnut husk fly	Jun-Sept	Neonicotinoid	Imidacloprid	Pasada	Jun-Aug
			Organophosphate	Chlorpyrifos	Lorsban	Jun-Aug
				Malathion	Clean crop	Jun-Aug
				Phosmet	Imidan	Jun-Aug
			Pyrethroid	Cyfluthrin	Leverage	Jun-Aug
				Esfenvalerate	Asana	Jun-Aug
			Spinosyn	Spinetoram	Delgate	Jun-Aug
				Spinosad	Naturalyte	Jun-Aug

[1] For organization purposes, Pesticide Class includes categories that are not pesticides, such as bacterium.
AI – Active ingredient
NA – Not available; no PUR data available
Sources: CA DWR 2013; Daane et al. 1993; Elliott et al., 2004; IRAC , 2005; UC ANR, 2013; Zalom et al., 1999; Summers et al., 2007; Rice et al., 1972.

Several alternative options exist to manage high priority pests in each commodity (Table 31). For example, the highest priority pests for almonds in the ESJWQC region are navel orange worm, peach twig borer, and San Jose scale. Over 10 different classes of pesticides, in addition to diazinon and chlorpyrifos, can be used to manage these pests (Table 31). Similarly, nine pesticides can be used to manage the same peach twig borer and San Jose scale in peaches, and seven to manage the same pests in prunes. In addition to the numerous alternative pesticides available, the timing of application varies both by pesticide choice and target pest (Table 31). For example, applications of pyrethroids are recommended for almonds in August to treat navel orange worm, but pyrethroids can also be applied in November through February to target peach twig borer in almonds (Table 31).

To determine which of these recommended pesticides might be used by growers as alternatives to chlorpyrifos and diazinon, the ESJWQC reviewed trends in the use of diazinon, chlorpyrifos, and alternative pesticides per each commodity using PUR data. The analysis includes applications starting in 2007 (the first year that general outreach focused on alternative strategies) through 2012 (Table 32).

Table 32 includes the average rate of change in use per year for each pesticide group per commodity. While the table highlights those pesticides with larger than 25% change per year, it is important to note that in some cases a small percent change may also represent clear directional changes in crops that have very high average pesticide use. Also, large yearly trends are often obscured by large variation among years (Table 32). For example, in alfalfa, the applications of chlorpyrifos declined 3,000 pounds between 2007 and 2012, but during 2009 applications actually increased by more than 10,000 pounds. Despite this large variability, it is clear that all seven of the top crops received decreasing applications of chlorpyrifos and/or diazinon over the time period.

Table 32. Trends in the use of chlorpyrifos, diazinon, and alternative pesticides applied per year to crops in the ESJWQC region since 2007.

Colors highlight pesticide classes that increase (green) or decrease (red) in usage by more than 25%. All PUR data are considered preliminary until received from CalPIP; CalPIP data are available through December 2011. The PUR data available from the counties in the ESJWQC region are incomplete for 2013.

Commodity	Pesticide Class [1]	Pounds of Active Ingredient						Percent Change [2]
		2007	2008	2009	2010	2011	2012	
Alfalfa	Chlorpyrifos	13174	16824	35575	16270	8494	10132	-10%
	Oxadiazine	1063	5654	2010	3112	1685	395	-17%
	Pyrethroid	856	907	1195	1444	1279	2971	24%
	Other organophosphate[3]	21304	22758	15989	16631	13779	13930	-10%
Almonds	Avermectin	0	0	0	1	193	252	71%
	Bacterium	9996	4642	5115	240	285	890	-51%
	Benzoylurea	7832	8897	10571	10559	9919	8400	2%
	Carbamate	60	45	40	1083	1101	183	33%
	Chlorpyrifos	77309	39804	39359	41207	34136	27339	-18%
	Diacylhydrazine	9752	11290	5429	15674	12465	15575	10%
	Diamide	0	0	4799	4354	6070	7129	41%
	Diazinon	4573	2587	2802	776	1205	625	-35%
	Hormone	360	427	739	712	941	983	19%
	Neonicotinoid	0	253	259	597	952	742	38%
	Pyrethroid	9172	8314	7094	38024	23040	46450	34%
	Spinosyn	407	313	156	41	109	102	-34%
	Other organophosphate[3]	6524	2617	669	1035	225	8	-61%
	Unclassified-Buprofezin	428	169	143	90	2	9	-54%
Corn	Bacterium	209	297	0	0	28	151	-27%
	Carbamate	2836	2147	1748	821	583	157	-39%
	Chlorpyrifos	9242	16882	12889	6819	11830	6362	-10%
	Pyrethroid	976	528	1405	1185	1739	1308	12%
	Spinosyn	10	3	1	2	0	39	42%
Grapes	Carbamate	47	0	270	886	0	467	28%
	Chlorpyrifos	15556	10287	23332	17831	10006	8225	-9%
	Neonicotinoid	4099	5077	6225	9454	12364	7828	17%
	Other organophosphate[3]	42	0	0	0	0	0	-86%
	Unclassified-Buprofezin	1203	1761	5485	6244	519	223	-9%

Commodity	Pesticide Class [1]	Pounds of Active Ingredient						Percent Change [2]
		2007	2008	2009	2010	2011	2012	
Peaches	Bacterium	749	197	277	91	89	195	-35%
	Benzoylurea	50	103	137	204	194	148	17%
	Carbamate	390	95	202	15	128	0	-42%
	Diacylhydrazine	843	682	594	453	460	558	-11%
	Diamide	0	86	234	351	535	489	40%
	Diazinon	2888	1237	1750	561	415	63	-44%
	Hormone	0	0	5	2	2	5	32%
	Pyrethroid	1190	821	1193	652	574	1093	-5%
	Spinosyn	247	143	87	99	75	54	-28%
Prunes	Bacterium	0	54	65	41	0	0	-20%
	Chlorpyrifos	333	364	383	480	142	0	-22%
	Diacylhydrazine	0	2	0	0	0	24	76%
	Diazinon	1131	947	596	344	368	11	-38%
	Hormone	0	1	7	0	0	0	-21%
	Pyrethroid	63	66	53	75	115	122	16%
	Spinosyn	6	0	0	0	0	0	-86%
	Other organophosphate[3]	76	248	797	250	524	314	11%
Walnuts	Avermectin	0	0	0	0	1	6	81%
	Benzoylurea	100	65	66	72	9	128	-1%
	Carbamate	0	0	0	209	0	10	20%
	Chlorpyrifos	28861	24613	23126	23224	18653	20733	-7%
	Diacylhydrazine	525	759	436	572	531	980	8%
	Diamide	0	3	316	285	580	549	44%
	Neonicotinoid	16	12	145	253	370	612	51%
	Pyrethroid	1037	802	930	1087	1202	1567	10%
	Spinosyn	112	56	91	94	153	112	8%
	Other organophosphate[3]	11834	10997	9576	6531	7319	4873	-16%

[1] Active Ingredients of pesticide classes are listed in Table 31.
[2] The percent change is the average change across all years, calculated as the slope of the regression of the pounds of pesticide as a function of year, divided by the average use over the whole period.
[3] Other organophosphates refers to all pesticides classified as organophosphates except chlorpyrifos and diazinon.

Keeping in mind that trends among years are not linear, all focus crops have had changes in pesticide use over time. For instance, regarding chlorpyrifos applications to alfalfa, there was an increase in use from 2007 through 2009, a decrease from 2009 through 2011 and a slight increase from 2011 through 2012. However, the overall trend was a decrease in use from 2007 through 2012 (Table 32). The overall decrease may be due to an increase in the use of pyrethroids (Table 32). In almonds, there was a small but steady decrease in the use of chlorpyrifos, and a large and clear decrease in the use of diazinon and other organophosphates. Conversely, there were increases in the use of avermectins, carbamates, diamides, neonicotinoids, and pyrethroids (Table 32). In corn, the chlorpyrifos applications increased from 2007 through 2009 only to decrease and increase annually from 2010 through 2012 with the lowest amount of pounds applied in 2012 (Table 32). Pyrethroids and spinosyns potentially replaced some use of chlorpyrifos on corn for pests like corn earworm. In grapes there has been an overall decrease in the use of chlorpyrifos from 2009 through 2012 (Table 32), and an increase in the use of carbamates and neonicotinoids. In peaches there was a steady decrease in the use of diazinon and a small increase in the use of diamides. In prunes there was a large decrease in the use of diazinon and chlorpyrifos, and an uneven increase in the use of other pyrethroids and other organophosphates.

Finally, in walnuts there was a small but steady decrease in the use of chlorpyrifos, and an increase in the use of diamides, and neonicotinoids.

These trends suggest that pesticide use in the ESJWQC is changing. Farmers are using less chlorpyrifos or diazinon, and using different pesticide classes more often. However, it is important to keep in mind that these trends in pesticide use are not corrected for changes in the acreage of the different crops over time or the relative toxicity of the different pesticides to the target pests. Hence increases or decreases in yearly applications may also reflect increases or decreases in crop areas. Also, many changes in pesticide use may be explained by pesticide rotations to avoid pest resistance or changes in pest pressure from year to year. Finally, with these data it is not possible to determine if pesticides were used in place of chlorpyrifos or diazinon, or if they were applied in response to the presence of a different pest, or applied during a different phase of the life cycle of a common insect pest.

The ESJWQC monitored for some alternative pesticides during 2013 (Table 33). The ESJWQC sampled 15 tributary sites for potential alternative pesticides and/or for water column and sediment toxicity which could indicate the presence of alternative pesticides.

Table 33. The ESJWQC tributary monitoring schedule for potential alternatives to chlorpyrifos and diazinon during the 2013 WY.

Subarea	Tributary Station Name	Organophosphates											Carbamates						Toxicity		
		Azinphos-methyl	Dichlorvos	Dimethoate	Demeton-s	Disulfoton	Malathion	Methamidophos	Methidathion	Parathion, methyl	Phorate	Phosmet	Aldicarb	Carbaryl	Carbofuran	Methiocarb	Methomyl	Oxamyl	*C. dubia*	*P. promelas*	*H. azteca*[1]
Bear Creek, Fresno-Chowchilla	Berenda Slough along Ave 18 ½	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12
	Black Rascal Creek @ Yosemite																		MPM13		
	Deadman Creek @ Gurr Rd																		MPM13	MPM13	
	Deadman Creek @ Hwy 59	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12
	Dry Creek @ Rd 18																				MPM13
	McCoy Lateral @ Hwy 140	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12
	Miles Creek @ Reilly Rd	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13, MPM13	A13	A13, MPM13
	Unnamed Drain @ Hwy 140	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13
Tuolumne River, Northeast Bank	Dry Creek @ Wellsford Rd																				MPM13
	Mootz Drain downstream of Langworth Pond	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13
Stanislaus River, North Stanislaus	Rodden Creek @ Rodden Rd	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12
Turlock, Merced	Highline Canal @ Lombardy Rd	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12	A12, MPM13	A12	A12, MPM13
	Levee Drain @ Carpenter Rd	A12, A13	A12, A13	A12, A13	A12, A13	A12, A13	A12, A13	A12, A13	A12, A13	A12, A13	A12, A13	A12, A13	A12, A13	A12, A13	A12, A13	A12, A13	A12, A13	A12, A13	A12, A13	A12, A13	A12, A13
	Merced River @ Santa Fe																		MPM13		
	Mustang Creek @ East Ave	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13	A13
	Total Samples Collected	**63**	**63**	**63**	**63**	**63**	**63**	**63**	**63**	**63**	**63**	**63**	**63**	**63**	**63**	**63**	**63**	**63**	**77**	**68**	**69**

[1]If *H. azteca* survival is less than 80% compared to the control, the following pesticides are analyzed: bifenthrin, cyfluthrin, cypermethrin, deltamethrin, esfenvalerate, lambda-cyhalothrin, permethrin, fenpropathrin and chlorpyrifos. Sediment samples are only collected twice a year.

A12- Assessment Monitoring for constituent during 2012 (October-December)

A13- Assessment Monitoring for constituent during 2013 (January-September)

MPM13-Management Plan Monitoring for constituent during 2013 (during months of past exceedances)

Samples collected from Miles Creek @ Reilly Rd on April 2, 2013 indicated the presence of malathion (Table 34). There is a prohibition of discharge of malathion for all Coalitions except for the Rice Coalition and any detection of malathion is considered an exceedance. The PUR data indicate that in March and April there were applications of malathion to alfalfa and citrus.

Table 34. Water column detections of potential alternative pesticides in ESJWQC tributaries during the 2013 WY.

Associated WQTLs per each pesticide are listed in parenthesis in the header row; exceedances are bolded.

Subarea	Tributary Station Name	Sample Date	Malathion (0 mg/L)
Bear Creek, Fresno-Chowchilla	Miles Creek @ Reilly Rd	4/2/2013	0.078
		Total Exceedances	**1**
		Percentage of Exceedances Compared to Total Samples	**<0.01%**

Monitoring results indicate nine instances of toxicity: five water column samples were toxic, four to *Ceriodaphnia dubia* and one to *Pimephales promelas*; four sediment samples were toxic to *Hyalella azteca* (Table 35). Of the water column toxicity events, Toxicity Identification Evaluation (TIE) analyses indicate that the *C. dubia* toxicities on March 12 and August 13 were caused by OP insecticides. The toxicity to *C. dubia* and *P. promelas* on February 12 and July 9 were caused by ammonia. Sediment toxicity to *H. azteca* on March 12 and September 9 were associated with use and/or detections of pyrethroids and chlorpyrifos (Table 35 and Table 36).

Monitoring results in 2013 indicate malathion and pyrethroids were present in tributaries within the ESJWQC region (Table 34 and Table 36), and toxicity evaluations showed pyrethroids were associated with impaired water quality (Table 35). Pyrethroids are one of the top four alternatives applied on alfalfa, almonds, corn, peaches, prunes, and walnuts (Table 32).

Table 35. The ESJWQC tributary water column and sediment toxicity exceedance summary for the 2013 WY.

Subarea	Station Name	Sample Date	Season & Monitoring Type[1]	Species	Toxicity End Point	Mean	Percent Control	Toxicity Significance	Summary Comments
Turlock, Merced	Levee Drain @ Carpenter Rd	2/12/2013	Winter2, NM	*C. dubia*	Survival (%)	50	50	SL	The TIE indicated ammonia caused the toxicity.
Turlock, Merced	Levee Drain @ Carpenter Rd	2/12/2013	Winter2, NM	*P. promelas*	Survival (%)	0	0	SL	The TIE indicated ammonia caused the toxicity.
Bear Creek, Fresno-Chowchilla	Duck Slough @ Gurr Rd	3/12/2013	Winter3, MPM	*C. dubia*	Survival (%)	0	0	SL	The TIE indicated organophosphate insecticides caused the toxicity.
Turlock, Merced	Hatch Drain @ Tuolumne Rd	3/12/2013	Winter3, MPM, SED	*H. azteca*	Survival (%)	71	72	SL	Pyrethroids and chlorpyrifos detected.
Turlock, Merced	Levee Drain @ Carpenter Rd	7/9/2013	Irrigation4, NM	*C. dubia*	Survival (%)	35	35	SL	The TIE indicated ammonia caused the toxicity.
Turlock, Merced	Prairie Flower Drain @ Crows Landing Rd	8/13/2013	Irrigation5, MPM	*C. dubia*	Survival (%)	0	0	SL	The TIE indicated organophosphate insecticides caused the toxicity.
Bear Creek, Fresno-Chowchilla	Dry Creek @ Rd 18	9/10/2013	Irrigation6, MPM	*H. azteca*	Survival (%)	88	92	SG	PUR data indicate pyrethroid applications of beta-cyfluthrin, bifenthrin, chlorpyrifos, cyfluthrin, esfenvalerate, lambda-cyhalothrin, permethrin, and pyrethrins occurred on fields that drain into Dry Creek; the cause of the toxicity is unknown.
Bear Creek, Fresno-Chowchilla	Duck Slough @ Gurr Rd	9/10/2013	Irrigation6, MPM	*H. azteca*	Survival (%)	0	0	SL	Pyrethroids and chlorpyrifos detected.
Turlock, Merced	Hatch Drain @ Tuolumne Rd	9/10/2013	Irrigation6, MPM, SED	*H. azteca*	Survival (%)	82	85	SG	PUR data indicate pyrethroid applications of bifenthrin, chlorpyrifos, lambda-cyhalothrin, and permethrin occurred on fields that drain into Hatch Drain; the cause of the toxicity is unknown.

[1]Season & Sample Type column includes the type of monitoring the toxic species was undergoing during the month of monitoring.
NM-Normal Monitoring
SED-Sediment monitoring
SL-Statistically significantly different from control; less than 80% threshold
SG-Statistically significantly different from control; greater than 80% threshold
TIE-Toxicity Identification Evaluation

Table 36. The ESJWQC tributary chlorpyrifos and pyrethroid results for toxic sediment samples collected during the 2013 WY.

Subarea	Station Name	Sample Date	*H. azteca* (% Control)	Sediment Pesticides µg/kg dw								
				Bifenthrin	Chlorpyrifos	Cyfluthrin	Cyhalothrin, Lambda	Cypermethrin	Deltamethrin: Tralomethrin	Esfenvalerate/ Fenvalerate	Fenpropathrin	Permethrin
Turlock, Merced	Hatch Drain @ Tuolumne Rd	3/12/2013	72	25	7.2	ND	J0.95	ND	ND	ND	ND	ND
Bear Creek, Fresno-Chowchilla	Duck Slough @ Gurr Rd	9/10/2013	0	1.9	3.3	J0.14	46	ND	ND	3.5	0.36	0.40

J-Estimated value
ND- Not Detected

The Westside Coalition tests collected samples for a variety of carbamate, OP, and organochlorine insecticides (depending on the site). During the 2013 WY, there were 62 detections of insecticides at sites monitored by the Westside Coalition. Of these, 25 represented legacy insecticides that are no longer in use (such as DDT and endosulfan). Of the remaining detections, 32 were OP insecticides (12 detections of chlorpyrifos, 10 of diazinon, six of dimethoate, and four of malathion), and five were carbamates (one of carbaryl and four of methomyl).

The Westside Coalition collects sediment samples for toxicity testing in March and September of each year, and sediment pesticide analyses are performed as a follow-up to observations of sediment toxicity. During the 2013 WY, fourteen samples were collected (including one duplicate) and tested for toxicity to *H. azteca* on March 11th. Statistically significant toxicity was measured at five sites – three of which exhibited severe toxicity (<50% survival). Follow-up pesticide analysis for a variety of pyrethroids, legacy organochlorines and selected OP insecticides, were performed on those three samples. On September 9th, eleven sediment samples were collected and tested for sediment toxicity (including 1 duplicate), of which five showed significant toxicity. Four of those samples were tested for selected pesticides. Of the seven sediment samples tested for pesticides, chlorpyrifos was detected above the RL in four. Sediment toxicity and pesticide detections are discussed in greater detail in Section 8 and Attachment 4 of the Westside Coalition's SAMRs.

The Westside Coalition also reviewed available PUR data to evaluate applications of insecticides. Table 37 lists the most applied insecticides (based on total application area).

Table 37. Insecticide applications within the Westside Coalition in order of highest application area.

Fresno County	Merced County	Stanislaus County
Bifentrhin	Lambda-cyhalothrin	Lambda-cyhalothrin
Dimethoate	Malathion	Dimethoate
Chlorpyrifos	Chlorpyrifos	Esfenvalerate
Lambda-cyhalothrin	Dimethoate	Bifenthrin
Malathion	Cypermethrin	Chlorpyrifos
Cypermethrin	Permethrin	Diazinon
Esfenvalerate	Methomyl	Carbaryl
Carbaryl	Esfenvalerate	Permethrin
Permethrin	Bifenthrin	Ziram
Acephate	Carbaryl	Cypermethrin
Methomyl	Diazinon	Fenpropathrin
Oxamyl	Beta-cyfuthrin	Malathion
Naled		Beta-cyfluthrin
Diazinon		Oxamyl
Ziram		Cyfluthrin
Beta-cyfluthrin		Acephate
Captan		Captan
Methamidophos		Methomyl

Alternatives Detected

The ESJWQC and Westside Coalition detected several pesticides that are alternatives to chlorpyrifos and/or diazinon, including alternatives recommended by PCAs for use on grapes, almonds, and walnuts. Some of these alternative pesticides were found to impair water quality by either exceeding their respective WQOs or contributing to toxicity. Below is a brief description of the detected pesticides:

- Bifenthrin is a pyrethroid insecticide used to treat a variety of insects in orchards and field crops such as alfalfa, cotton, tomatoes, and corn but also has significant residential use.
- Carbaryl is a wide-spectrum carbamate pesticide used as an insecticide, molluscicide and acaricide on a variety of citrus and nut trees and fruit and fiber crops.
- Cyfluthrin is a pyrethroid insecticide used to treat a variety of insects in orchards and field crops such as alfalfa, corn, tomatoes, and cotton.
- Cypermethrin is a pyrethroid insecticide used to treat a variety of insects in field crops such as alfalfa, cotton, onion, and cabbage.
- Dimethoate is an OP pesticide used to control a wide range of insects. It is used on a variety of field crops including alfalfa, beans, tomatoes, and cotton.
- Esfenvalerate/Fenvalerate is a synthetic pyrethroid insecticide which is used on a wide range of pests on vegetable crops, tree fruits, and nut crops. It may be mixed with a wide variety of other types of pesticides such as carbamate compounds or organophosphates
- Fenpropathrin is a pyrethroid insecticide used on a variety of fruit and vegetable crops.
- Lambda cyhaolthrin is a pyrethroid insecticide used to treat a variety of insects in orchards and field crops such as corn, tomatoes, and cotton.
- Malathion is an OP insecticide used on a variety of crops including alfalfa, walnuts, lettuce, grapes, and cotton.
- Methomyl is a carbamate insecticide used to control a variety of pests on vegetable, fruit, and field crops.
- Permethrin is a pyrethroid insecticide used to treat a variety of insects in orchards and field crops such as corn, tomatoes, and cotton and is also used for mosquito and residential insect control.

Although the Coalitions detected 11 different insecticides in waterways during this reporting period, and these may be used as alternatives to chlorpyrifos and/or diazinon, it is not possible to determine if any of these materials were selected as an alternative or as part of a grower's pesticide management rotation. Pesticide Control Advisors are recommending the use of some of these pesticides, but the PUR and monitoring data do not provide sufficient information for the Coalitions to establish if the detected pesticides were indeed from applications of pesticides used in an alternative capacity. It is a necessary cultural practice to rotate pesticide selection through specific modes of action (i.e. pyrethroids to organophosphates to carbamates) in order to minimize the risk of pesticide resistance. As a result of this practice, a material other than chlorpyrifos or diazinon may be select simply because it was next in the rotation rather than as a specific alternative. Based on the Coalition's conversations with growers and PCA's, regulatory pressure on diazinon use has phased that material out of the pest management

rotation. Chlorpyrifos continues to be a preferred material due to its wide range of allowable use and effectiveness. The Coalitions continue to educate growers through outreach of other applicable alternatives to chlorpyrifos.

OBJECTIVE 6: DETERMINE WHETHER THE DISCHARGE CAUSES OR CONTRIBUTES TO TOXICITY IMPAIRMENT DUE TO ADDITIVE OR SYNERGISTIC EFFECTS OF MULTIPLE POLLUTANTS.

The loading capacity and load allocation for chlorpyrifos and diazinon are based on current understanding of the two pesticides' additive effects (Figure 1). During the March 2013 sampling event, chlorpyrifos was detected in the San Joaquin River at Las Palmas sample (0.13µg/L). The only other detection of chlorpyrifos during that sample event occurred in the Poso Slough sample, more than 40 miles from the Las Palmas site. The PUR data indicate limited chlorpyrifos use in the vicinity of the Las Palmas sample. All other samples were in compliance with the load capacity (Appendix IV, Table IV-1). Chlorpyrifos and diazinon were detected together in three samples collected by the Westside Coalition.

In addition, as part of each Coalition's tributary monitoring strategies, the ESJWQC and Westside Coalition sample for a wide range of pesticides and toxicity. TIEs are conducted on toxic water samples to determine the cause of toxicity (if survival is 50% or less compared to the control). Toxic sediment samples are subject to further analysis for chlorpyrifos and pyrethroids (if survival is less than 80% compared to the control). From these results, the Coalitions are able to consider the additive and/or synergistic effects of multiple pollutants.

ESJWQC Evaluation of Toxicity Impairment Due to Additive or Synergistic Effects of Multiple Pollutants

To assess if toxicity occurred due to the additive or synergistic effects of chlorpyrifos or diazinon and another pollutant, the ESJWQC reviewed toxicity results for *C. dubia* and *P. promelas* in the water column and *H. azteca* in sediment samples. During the 2013 WY, four water column samples were toxic to *C. dubia*, one to *P. promelas*, and four sediment samples were toxic to *H. azteca* (Table 35).

Sediment chemistry analysis for pyrethroids and chlorpyrifos was performed on samples toxic to *H. azteca* from Hatch Drain @ Tuolumne Rd on March 12, 2013 and Duck Slough @ Gurr Rd on September 10, 2013. The additional sediment chemistry analyses indicated the presence of bifenthrin, chlorpyrifos, cyfluthrin, cyhalothrin lambda, esfenvalerate/fenvalerate, Fenpropathrin, and permethrin (Table 36).

Sediment samples collected on September 10, 2013 from Dry Creek @ Rd 18 and Hatch Drain @ Tuolumne Rd were toxic to *H. azteca.* However, survival was greater than 80% compared to the control and therefore additional sediment chemistry analysis was not required (Table 35). PUR data indicate that applications of pyrethroids occurred to parcels in the subwatershed prior to the sampling event (Table 36).

With the available data, it is not possible evaluate if the detected pesticides interacted in an additive or synergistic manner to cause the sediment toxicity.

Westside Coalition Evaluation of Toxicity Impairment Due to Additive or Synergistic Effects of Multiple Pollutants

The Westside Coalition reviewed aquatic and sediment toxicity results to assess if toxicity occurred due to the additive or synergistic effects of chlorpyrifos or diazinon and another pollutant. During the 2013 WY, eight samples were toxic to *C. dubia*, two samples were toxic to algae, and nine sediment samples were toxic to *H. azteca*. Table 38 and Table 39 provide details regarding the survival, follow-up testing, and apparent causes. With the exception of one sample from Del Puerto Creek near Cox Road (June, 2013), pesticides were detected in all of the samples exhibiting aquatic toxicity. Multiple pollutants (including chlorpyrifos or diazinon) were found in five of the nine samples. During the June 2013 sample event, one of the control sample sets for the *C. dubia* samples failed to meet the survival criteria, resulting a retest of six samples. In the initial testing during that sample event, the Del Puerto Creek near Cox Road sample exhibited no toxicity (100% survival); however the retest of that sample measured 10% survival. A TIE was performed however the toxicity was not persistent and the TIE was inconclusive. No pesticides were detected in the sample and the cause of toxicity is unknown.

Chlorpyrifos and diazinon were detected together in three samples; two from Hospital Creek and one from Ingram Creek. In all three samples, the concentration of both chlorpyrifos and diazinon was high enough that toxicity would be expected from either material on its own. Interestingly, toxicity to *C. dubia* occurred only in the Ingram Creek sample; toxicity results from the May and June Hospital Creek samples did not exhibit significant toxicity. See the Westside Coalition November 30, 2013 SAMR (Attachment 2), and Appendix IV.

Table 38. Westside Coalition tributary water column toxicity exceedance summary for 2013 WY.

Station Name	Sample Date	Reactive Species	Results	Units	TIE Comments	Apparent Cause
Ingram Creek @ River Road	1/8/13	*Selenastrum capricornutum*	95.5	% Difference	TIE indicated pesticides are likely the cause.	Diuron (44µg/L), Prowl (1.0µg/L), Prowl (1.0µg/L), and Simazine (5.0µg/L)
Ingram Creek @ River Rd.	3/12/2013	*Selenastrum capricornutum*	46	% Difference	TIE indicated pesticides are likely cause.	Diuron (8.4µg/L)
Poso Slough @ Indiana Ave.	3/12/2013	*Ceriodaphnia dubia*	0	% Survival	Tie indicated pesticides are the likely cause	Chlorpyrifos (0.13µg/L) and Malathion (3.9µg/L)
Salt Slough @ Sand Dam	3/12/2013	*Ceriodaphnia dubia*	0	% Survival	TIE indicated pesticides are the likely cause.	Malathion (2.7µg/L)
Del Puerto Creek @ Cox Rd.	5/14/2013	*Ceriodaphnia dubia*	0	% Survival	TIE indicated pesticides are the likely cause.	Carbaryl (7.3µg/L)
Ingram Creek @ River Road	5/14/2013	*Ceriodaphnia dubia*	5	% Survival	TIE indicated pesticides are the likely cause.	Chlorpyrifos (0.27µg/L), Diazinon (0.55µg/L), DDE (0.018µg/L), and HCH (0.016µg/L)
Marshall Road Drain near River Road	5/14/2013	*Ceriodaphnia dubia*	0	% Survival	TIE indicated pesticides are likely cause.	Diazinon (2.9µg/L)
Orestimba Creek	5/14/2013	*Ceriodaphnia dubia*	0	% Survival	TIE indicated pesticides are likely the cause.	DDE (0.012µg/L) and Diazinon (1.3µg/L)

Station Name	Sample Date	Reactive Species	Results	Units	TIE Comments	Apparent Cause
Del Puerto Creek near Cox Road	6/11/2013	*Ceriodaphnia dubia*	10	% Survival	Toxicity was not persistent in the TIE and the cause could not be determined.	No pesticides were detected.
Ingram Creek @ River Road	6/11/2013	*Ceriodaphnia dubia*	0	% Survival	TIE indicated pesticides are likely cause.	DDE (0.04µg/L), Diazinon (1.1µg/L), and Toxaphene (0.41j µg/L)

Evaluation of Detected Sediment Pesticides

March 2012 Sediment Toxicity Follow Up

Sediment toxicity tests were performed on 14 samples (including one duplicate) collected in March (Event 100). In March 2012, statistically significant toxicity was measured at five sites (Table 39), although two of the five measured survival at or greater than 90%. Follow up pesticide testing was performed on the three samples exhibiting severe toxicity. These results were compared to literature values for the purpose of determining the probable cause of toxicity in each sample. In all cases pesticides were present in sufficient quantity to have caused the toxicity.

- Blewett Drain at Highway 13 (3.75% survival): A total of 2.33 sediment toxic units (TUs) were calculated based on the detected pesticides. Bifentrhin accounted for 1.88 TUs, esfenvalerate accounted for 0.34 TUs and chlorpyrifos accounted for 0.6 TUs.
- Ingram Creek (1.25% Survival): 5.53 TUs were calculated, with bifenthrin and lambda cyhalothrin, and chlorpyrifos accounting for 2.78 TUs, 1.4 TUs, and 1.04 TUs, respectively.
- Westley Wasteway (1.25% Survival): A total of 4.66 TUs, with bifentrhin, chlorpyrifos, and lambda cyhalothrin accounting for 3.79 TUs, 0.65 TUs, and 0.13 TUs, respectively.

September 2013 Sediment Toxicity Follow Up

Sediment toxicity test were performed on 11 samples (including one duplicate) collected in September 2013 (Event 106). Statistically significant toxicity was measured at five sites, four of which were sufficient to required follow-up pesticide analysis (see Table 39). These results were compared to literature values for the purpose of determining the probable cause of toxicity in each sample.

- The Del Puerto Creek at Highway 33 sample had a total of 0.47 TUs, with bifenthrin accounting for 0.44 TUs. This is relatively consistent with the 58.8% survival observed.
- The Hospital Creek sample had a total of 7.2 TUs, with lambda-cyhalothrin accounting for 5.93 TUs and bifenthrin accounting for 1.09 TUs. Chlorpyrifos accounted for 0.05 TUs. There were sufficient pyrethroid TUs to account for the 0% amphipod survival observed in the sample.
- The Ingram Creek sample had a total of 3.85 TUs, with bifenthrin, lambda cyhalothrin, and esfenvalerate accounting for 1.00 TUs, 2.33 TUs, and 0.11 TUs, respectively. Cypermethrin accounted for 0.37 TUs and chlorpyrifos accounted for 0.04 TUs. There were sufficient pyrethroid TUs to account for the 0% amphipod survival observed in the sample.

- The Westley Wasteway sample had a total of 2.85 TUs, with bifenthrin, lambda-cyhalothrin, cyfluthrin, and esfenvalerate accounting for 2.60 TUs, 0.11 TUs, 0.07 TUs, and 0.06 TUs, respectively. Chlorpyrifos accounted for 0.01 TUs. There were sufficient pyrethroid TUs to account for the 2.5% amphipod survival observed in the sample.

Table 39. The Westside Coalition tributary sediment toxicity exceedance summary for the 2013 WY.

Station Name	Sample Date	Reactive Species	% Survival	Detected Pesticides
Belwett Drain @ Hwy 132.	3/16/13	*Hyalella azteca*	3.75	Bifenthrin (13 ng/g), Chlorpyrifos (0.63 ng/g), Cyhalothrin (0.16j ng/g), DDE (15 ng/g), Esfenvalerate (3.2 ng/g).
Ingram Creek @ River Rd.	3/16/2013	*Hyalella azteca*	1.25	Bifenthrin (11 ng/g), Chlorpyrifos (14 ng/g), Cyfluthrin (1.1 ng/g), Lymbda cyhalothrin (4.8 ng/g). Cypermethrin (0.26j ng/g), DDE (120 ng/g), Esfenvalerate (0.99 ng/g).
Westley Wasteway near Cox Rd.	3/16/2013	*Hyalella azteca*	1.25	Bifenthrin (36 ng/g), Chlorpyrifos (21 ng/g), Lambda cyhalothrin (1.1 ng/g), DDE (57 ng/g), Esfenvalerate (2.5 ng/g)
Ramona Lake near Fig Ave.	3/16/13	*Hyalella azteca*	91.25	No follow-up testing required
Newman Wasteway near Hills Ferry Rd.	3/16/13	*Hyalella azteca*	90	No follow-up testing required
Hospital Creek @ River Rd.	9/14/2013	*Hyalella azteca*	0	Bifenthrin (0.85 ng/g), Chlorpyrifos (0.13j ng/g), Lambda cyhalothrin (4 ng/g), DDE (23 ng/g), Esfenvalerate (0.32j ng/g)
Ingram Creek @ River Rd.	9/14/2013	*Hyalella azteca*	0	Bifenthrin (4.1 ng/g), Chlorpyrifos (0.59 ng/g), Lambda cyhalothrin (8.3 ng/g), Cypermethrin (1.1 ng/g), DDE (22 ng/g), Esfenvalerate (1.3 ng/g)
Westley Wasteway near Cox Rd.	9/14/2013	*Hyalella azteca*	2.5	Bifenthrin (23 ng/g), Chlorpyrifos (0.2j ng/g), Cyfluthrin (1.2 ng/g), Lambda cyhalothrin (0.86 ng/g), Esfenvalerate (1.7 ng/g)
Del Puerto Creek at Hwy 33	9/14/2013	*Hyalella azteca*	58.8	Bifenthrin (5ng/g), Lambda cyhalothrin (0.19j ng/g), Esfenvalerate (0.38 ng/g), Fenpropathrin (0.16j ng/g)
Los Banos Creek at China Camp Rd.	9/14/2013	*Hyalella azteca*	80	No follow-up testing required.

In each of the sediment samples where follow-up pesticide analyses were performed, at least one pyrethroid insecticide was detected at a level sufficient to cause the observed toxicity itself. Hence, synergistic effects between chlorpyrifos and other materials were unlikely.

OBJECTIVE 7: DEMONSTRATE THAT MANAGEMENT PRACTICES ARE ACHIEVING THE LOWEST PESTICIDE LEVELS TECHNICALLY AND ECONOMICALLY ACHIEVABLE

A determination of technical and economic feasibility needs to be done at the individual farm level and, consequently, is expected to vary with the specific operation and commodity farmed. The goal of the ESJWQC and Westside Coalitions is for their members to have no discharge of pesticides to surface waters. Economic feasibility is determined by factors outside the control of the Coalitions. Profitable operations can afford to implement management practices such as constructing sediment basins or installing pressurized irrigation, both of which can significantly reduce the runoff of irrigation and storm water carrying agricultural discharges. Marginally profitable operations may not be able to afford these

practices. Consequently, efforts by the ESJWQC and Westside Coalition to obtain additional funding for growers have been important to achieving the Coalitions' goal. Both Coalitions have been instrumental in helping growers obtain AWEP funding and publicizing the current funding available through the Proposition 84 grant program run by the Coalition for Urban/Rural Environmental Stewardship (CURES) as well as NRCS funding and internal grant/loan funding provided by local water agencies. These programs offer several million dollars towards the implementation of structural management practices within their respective regions. However, there remain many growers in the eastside drainage area of the SJR who are not members of either Coalition and not influenced by the Coalitions' efforts.

It is technically feasible to eliminate all discharges of chemicals to surface waters, although it could require steps that are not economically feasible for even the most profitable operations. Given the success in the ESJWQC and Westside Coalition regions in the 2013 WY, it seems possible to reduce discharges to surface waters to the point that they do not impair beneficial uses.

During the 2013 WY, an increase in exceedances of the WQTLs of both chlorpyrifos and diazinon was observed compared to the 2012 WY. However, within both the ESJWQC and Westside Coalition regions, there has been a reduction in the number of exceedances since the 2010 WY. The new membership enrollment in ESJWQC increased in 2013; however there still are numerous non-members in the Coalition that could be contributing to exceedances and who have not received focused outreach. Until the Coalition get 100% membership it's not entirely possible to determine who is discharging and therefore it is not possible to determine if growers in the ESJWQC are achieving the lowest pesticide levels achievable. Consequently, the management practices implemented by members of the Coalition appear to be resulting in a reduction of discharges, and are in the process of achieving the lowest pesticide levels technically and economically feasible.

CONCLUSIONS AND RECOMMENDATIONS

The ESJWQC and Westside Coalition assessed compliance with the seven Monitoring Objectives of the chlorpyrifos and diazinon TMDL program by evaluating results collected from their joint chlorpyrifos and diazinon TMDL monitoring program and their individual Coalition tributary monitoring programs. During the 2013 WY there was one exceedance of the WQO for chlorpyrifos in the San Joaquin River at Las Palmas Avenue near Patterson on March 2013. The Basin Plan states that WQOs for chlorpyrifos and diazinon are "*not to be exceeded more than once in a three year period*" (p. III-6.01). Hence, the Coalitions are still in compliance with Monitoring Objective 1 as there have been no other exceedances of the WQOs since July 2010.

There was one detection of chlorpyrifos and one detection of diazinon in water samples collected from ESJWQC tributaries during the 2013 WY. Prior to the 2013 exceedance of chlorpyrifos in the Tuolumne River, Northeast Bank subarea (Table 22), the last detection of chlorpyrifos at the same subarea was in July 2010. Regarding the diazinon exceedance in the Bear Creek, Fresno-Chowchilla, there have been no detections of diazinon in any of the ESJWQC tributaries since the TMDL surveillance and monitoring program began in January 2010. As these are the only exceedances in the last 3 years, the ESJWQC was compliant with Monitoring Objective 2. In the Westside Coalition, chlorpyrifos was detected in twelve water samples (over six different monitoring events) and diazinon was detected in ten samples (over two monitoring events). All concentrations were measured in excess of the load criteria. Of all tributaries with chlorpyrifos or diazinon exceedances, all but one (Marshall Road Drain at River Road) are under a management plan. A focused management plan for the Marshall Road Drain subwatershed is in development.

Both Coalitions determined the degree of implementation and evaluated the effectiveness of management practices designed to reduce the off-site movement of chlorpyrifos and diazinon. The ESJWQC and Westside evaluated alternatives to chlorpyrifos and diazinon including use within the two Coalition regions and water quality impairments due to other pesticides. Alternative pesticides may be impairing water quality although more likely sediment quality; synergistic and/or additive effects do not appear to be occurring in ESJWQC and Westside Coalition tributaries.

Chlorpyrifos use in recent years has declined (Figure 4). Diazinon use declined dramatically in the Lower SJR watershed over the past few years (Figure 3). In addition, growers are cognizant of water quality concerns related to OP pesticides and implement management practices to prevent off-site movement of chlorpyrifos and diazinon. Both Coalitions include discussions of chlorpyrifos and diazinon during focused outreach to growers.

The monitoring frequency of the chlorpyrifos and diazinon TMDL program was originally designed to occur quarterly in the SJR and monitoring would occur during one month of each quarter to coincide with the greatest applications (2010 WY). Beginning on the the 2011 WY, monitoring frequency was increased to include monthly samples for three of the six compliance points, and beginning on the 2012

WY frequency was increased to six times a year for the other three compliance points. Despite the four-fold increase in monitoring frequency since 2010, there has been only one single exceedance of chlorpyrifos and no detections of diazinon in the SJR.

REFERENCES

California Department of Water Resources (CA DWR). 2013. California Irrigation Management Information System (CIMIS) management Homepage. Available online: http://wwwcimis.water.ca.gov/cimis/data.jsp (Accessed February 15, 2013).

Daane, K. M., G. Y. Yokota, J. W. Dlott. 1993. Dormant-season sprays affect the mortality of peach twig borer (Lepidoptera: Gelechiidae) and its parasitoids. Journal of Economic Entomology. 86: 1679-1685.

Elliott, B., L. Wilhoit, M. Brattesani, N. Gorder. 2004. Pest management assessment for almonds: Reduced-risk alternatives to dormant organophosphate insecticides. California Department of Pesticide Regulation (DPR). Available online: http://www.cdpr.ca.gov/docs/pestmgt/pubs/pm0401asmnt.pdf (Accessed March 7, 2013).

Insecticide Resistance Action Committee (IRAC). 2005. IRAC eManual MoA Classification 2005. Available online: http://www.irac-online.org/eClassification/(Accessed February 12, 2013)

Regents of the University of California Division of Agriculture and Natural Resources (UC ANR). 2013. Agricultural pests. Statewide Integrated Pest Management Program (IPM). Available online: http://www.ipm.ucdavis.edu/PMG/crops-agriculture.html (Accessed February 10, 2013).

Rice, R. E., R. A. Jones, J. H. Black. 1972 Dormant sprays with experimental insecticides for control of peach twig borer. California Agriculture. 26:14-15. Available online at: http://ucce.ucdavis.edu/files/repositoryfiles/ca2601p14-63918.pdf. Accessed 4/5/2013.

Summers, C., L. Godfrey, E. Natwick. 2007. Managing insects in alfalfa. IN C. G. Summers and D. H. Putnam, eds., Irrigated alfalfa management for Mediterranean and Desert zones. Chapter 9. Oakland: University of California Agriculture and Natural Resources Publication 8295. Available online: http://alfalfa.ucdavis.edu/IrrigatedAlfalfa/pdfs/UCAlfalfa8295Insects_free.pdf (Accessed February 16, 2013).

Zalom, F., M. Oliver, D. Hinton. 1999. Alternatives to chlorpyrifos and diazinon dormant sprays. Statewide Integrated Pest Management (IPM) Project, Water Resources Center and Ecotoxicology Program University of California, Davis. Available online: http://www.ipm.ucdavis.edu/PDF/PUBS/dormantsprayalternatives.pdf (Accessed February 2, 2013).