East San Joaquin Water Quality Coalition Watershed Evaluation Report

March 8, 2006

Watershed Setting

General Characteristics

ESJWQC Area Overview

The East San Joaquin Water Quality Coalition (ESJWQC) area includes Stanislaus, Merced, Madera, Tuolumne, and Mariposa Counties and the portion of Calaveras County that drains into the Stanislaus River (Figure 1). The region that drains into the Coalition area is bordered by the crest of the Sierra Nevada on the east and the San Joaquin River on the west, the Stanislaus River on the North to the San Joaquin River on the South. The southern portion of the Coalition area has been expanded from last year's description to now include the area that was formerly within the Root Creek Coalition area. Additionally, there are landholdings in the vicinity of the Lone Willow Slough watershed (west of the Eastside Bypass) that have joined the Westside Coalition. We have retained that area as part of the coalition for mapping purposes as we do not know the actual parcels that are part of the Westside Coalition.

The only surface water export from the Coalition area is northward via the San Joaquin River (SJR). This river drains east and west side California Central Valley (Valley) watersheds, though only east side watersheds are relevant with respect to the Coalition area. San Joaquin River water is eventually either exported to the San Francisco Bay through the Delta, or conveyed southward via the State Water Project and the Delta Mendota Canal. The Coalition area also includes within its boundaries six irrigation districts: Oakdale Irrigation District, Merced Irrigation District, Turlock Irrigation District, Modesto Irrigation District, Chowchilla Irrigation District and Madera Irrigation District. Water bodies may have both irrigation district and Coalition jurisdiction only when they convey both irrigation supply and agriculture return water. All land within the boundaries of the irrigation districts is part of the coalition, and the growers in those areas may join the coalition if they want.

Apart from the San Joaquin River which forms the south and east boundary of the coalition, there are five major rivers in the watershed other than the San Joaquin River: Fresno River, Chowchilla River, Merced River, Tuolumne River and Stanislaus River. These east side tributaries of the San Joaquin River drain the relatively larger Sierra Nevada range from east to west. Typically, only the Stanislaus, Merced, and Tuolumne Rivers maintain flow during the summer months. Flow in the Chowchilla and Fresno Rivers are intermittent to nonexistent as the irrigation season progresses into the fall and remains dry unless major storm events produce sufficient precipitation in the immediate vicinity of the River. Intermediate sized water bodies in the Coalition area (e.g. Dry Creek, Duck Slough, and Highline Canal) originate either in the Sierra Nevada foothills or the Valley itself and are tributaries to the major rivers. The remaining water bodies small in size (e.g. Prairie Flower Drain, Jones Drain, Mustang Creek) and are primarily agricultural canals and ditches that either convey water to one of the larger rivers or intermediate creeks/sloughs (Figure 2).

Although exact acreage is difficult to estimate due to rapidly changing land use, the Coalition area contains 1,186,889 acres that are considered irrigated agriculture (Table 1). For Stanislaus, Merced, Mariposa, Tuolumne, and Madera Counties, we used the DWR land use estimates for irrigated agriculture to determine total acreage. DWR does not provide land use data for Calaveras County. Instead, we used data from the County Agricultural Commissioner's office.

Table 1. Irrigated lands in ESJWQC - Stanislaus, Merced, Madera, Tuolumne, Calaveras and Mariposa Counties. Data from 2001 California Department of Water Resources (http://www.landwateruse.water.ca.gov/annualdata/landuse/2001/landuselevels.cfm)

County	Irrigated Land Area (acres)
Calaveras	976
Madera	295,000
Mariposa	297
Merced	510,500
Stanislaus	378,700
Tuolumne	1,416
Total	1,186,889

County land use statistics for Mariposa, Tuolumne, and the Stanislaus River watershed in Calaveras County are provided in Table 2. In the figures that are presented below, the irrigated agriculture is extremely difficult to find because the parcels are typically small and distributed throughout the foothills region of those three counties. Even using ArcGIS, the parcels are difficult to find, but can be identified on the coverages. Calaveras County does not have parcels with DWR land use data, so the location of the irrigated agriculture in the upper Stanislaus drainage was estimated by information on Pesticide Use Reports filed with the County Agricultural Commissioner using township, range and section.

Note that the estimates of irrigated acres are different from the estimates provided in the semi-annual report of January 3, 2006. The differences are the result of discussions with the Counties to gain a better understanding of exactly where and how much irrigated agriculture is present in the counties. We anticipate that as urban development increases over the next several years, the estimates will continue to change.

Figure 1. Coalition boundaries of the ESJWQC region. The map provided here is in jpg format and consequently does not support a reasonable level of detail. These maps are available as an ArcGIS coverage and can be manipulated to provide any level of detail desired. ArcGIS coverage is provided electronically along with this report.

ESJWQC - General Coalition Map

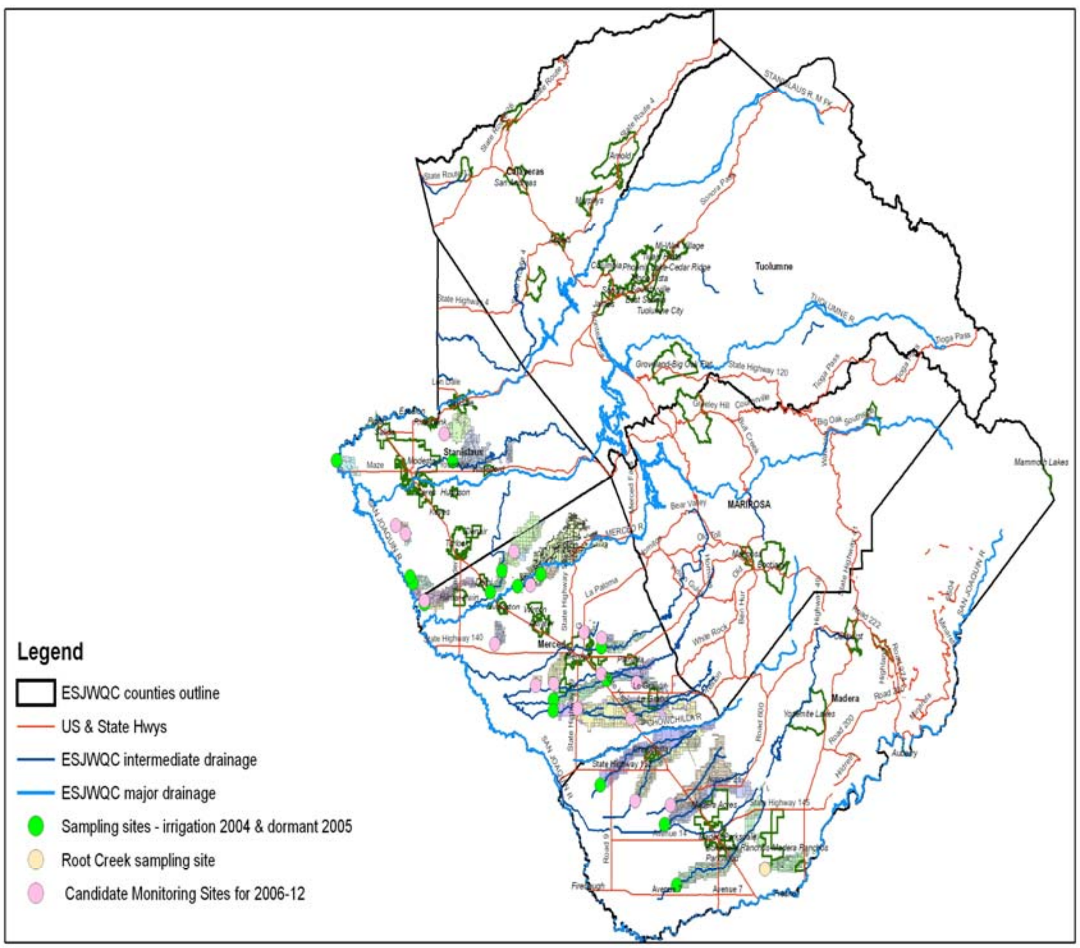
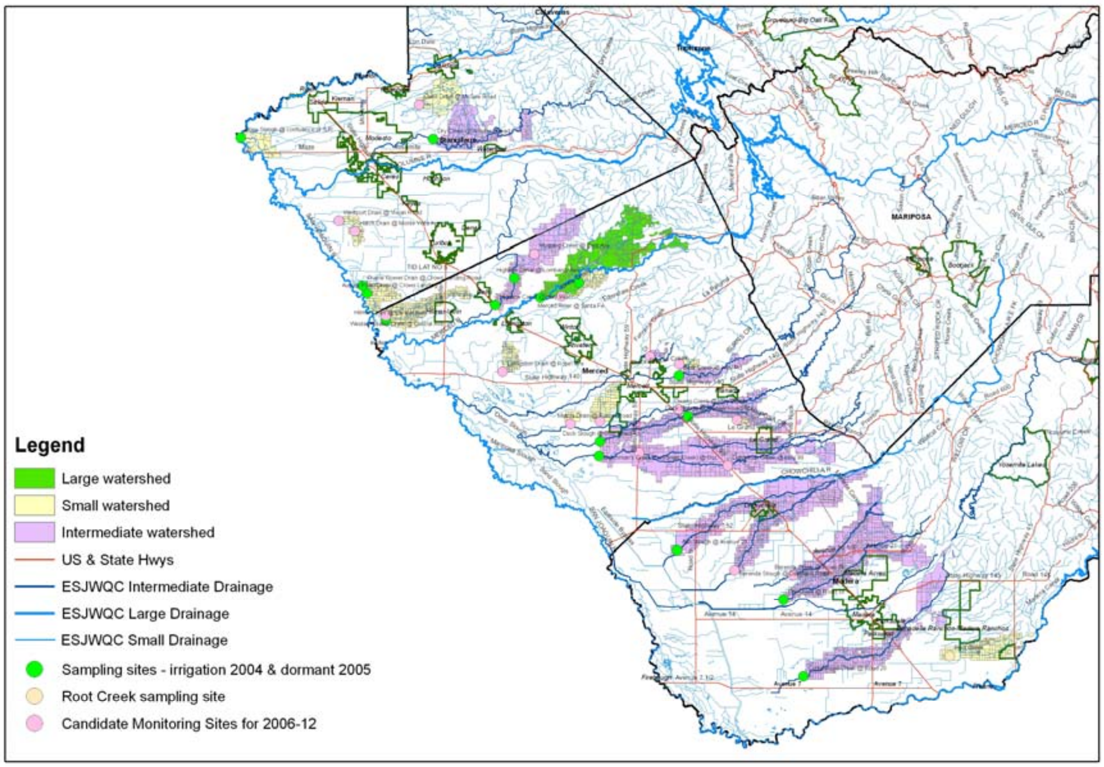


Figure 2. Drainage designation showing all subwatersheds in the coalition region. The map provided here is in jpg format and consequently does not support a reasonable level of detail. These maps are available as an ArcGIS coverage and can be manipulated to provide any level of detail desired. ArcGIS coverage is provided electronically along with this report.

ESJWQC - Watershed size designation



Land Use

Irrigated agriculture is the predominant land use in the Coalition area although growth of the urban areas in the Valley has been a significant factor impacting water quality. Non-irrigated land uses include primarily urban land uses with some acreage in feedlots and impoundments.

A variety of crops are grown and are often found in regions specific to microclimate, soil type, and local farming history. A more detailed discussion of crop type occurs in this report when each subwatershed is described. Over 50 types of commercial crops are produced within the coalition area (Table 3). The most common crops by acres are almonds, tomatoes, hay, sweet potatoes, cotton, silage, beans, wheat, peaches, melons, and grapes. In general agriculture varies geographically as one travels from the north to south and from east to west. In the eastern foothills, deciduous orchards and grapes are the dominant crops, though there is also considerable irrigated pasture and dairy farm. Crop type is more diverse in the northern Coalition area and includes row crops (e.g. tomatoes, sweet potatoes, melons, leafy green vegetables), alfalfa hay, and orchards. In the relatively drier southern area dominate crops include cotton, vineyard, and orchards (almonds and pistachios). The California Department of Pesticide Regulation database (http://calpip.cdpr.ca.gov/cfdocs/calpip/prod/main.cfm) is current through 2004. Crops grown in the remaining counties of the coalition region are provided in Table 2.

Land use maps for the coalition counties are provided in Figures 3-9. The legend for the land use is provided in Figure 10a.

Figure 3. Land use for counties in ESJWQC.

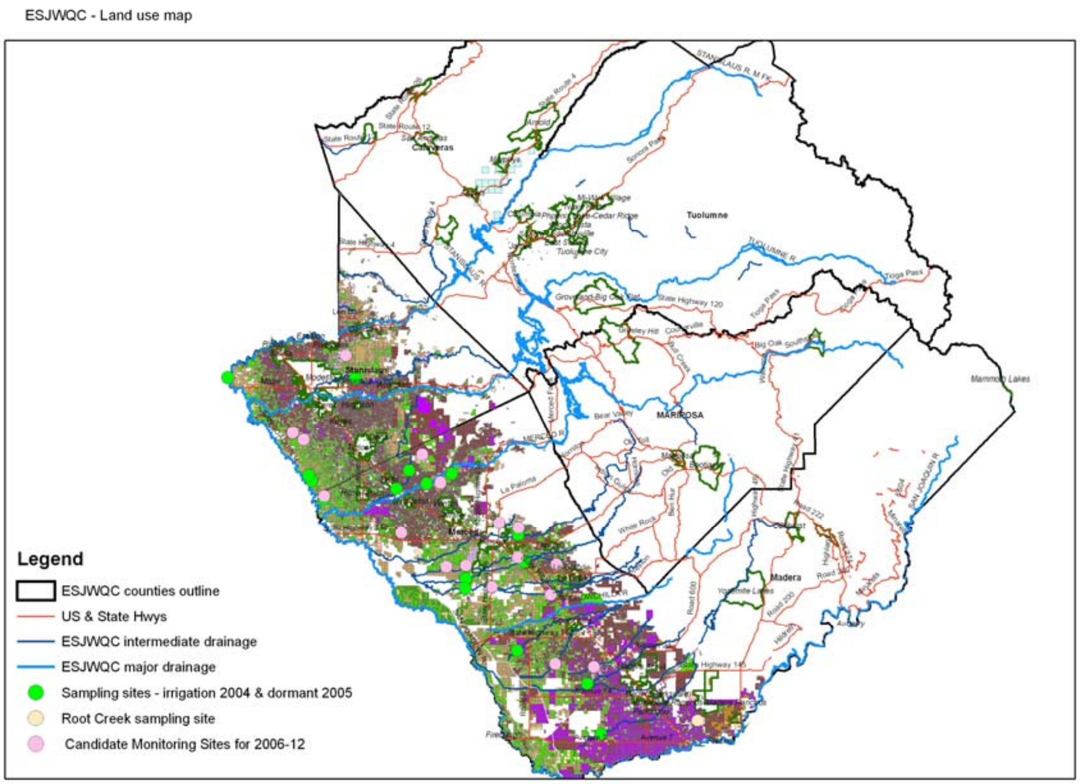


Figure 4. Land use for Stanislaus County.

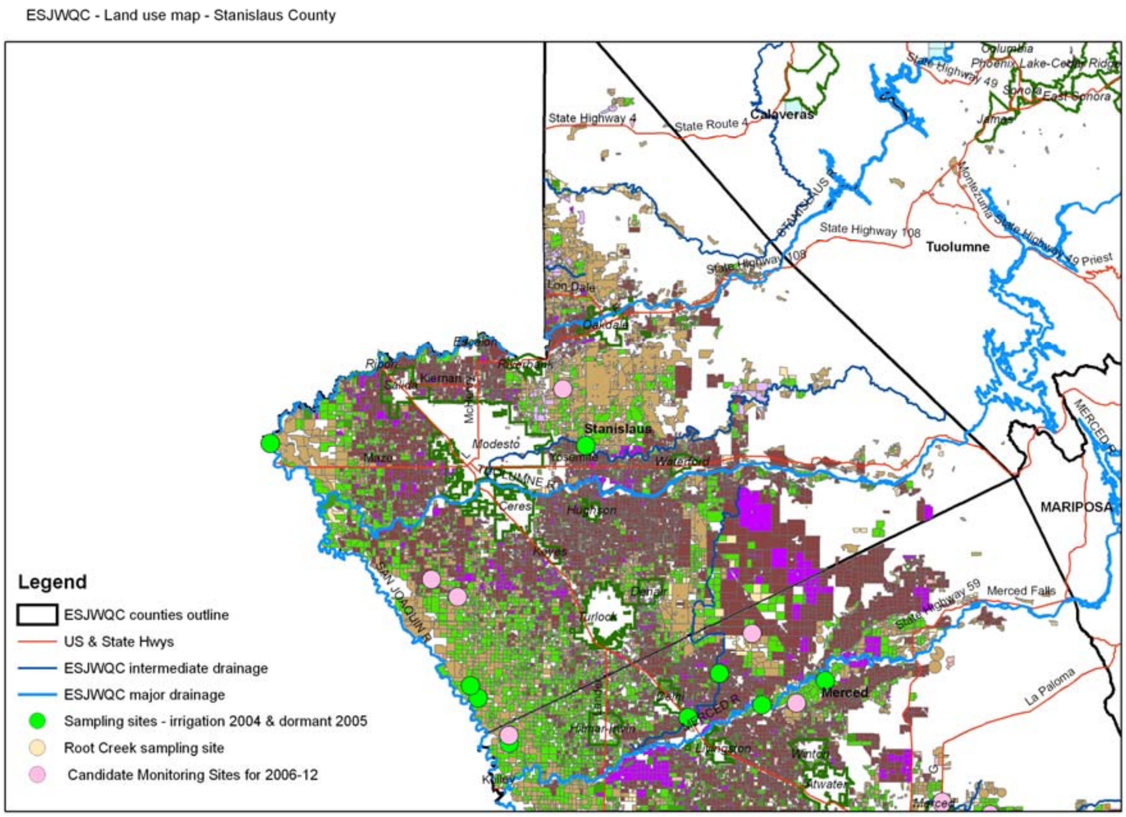


Figure 5. Land use for Merced County.

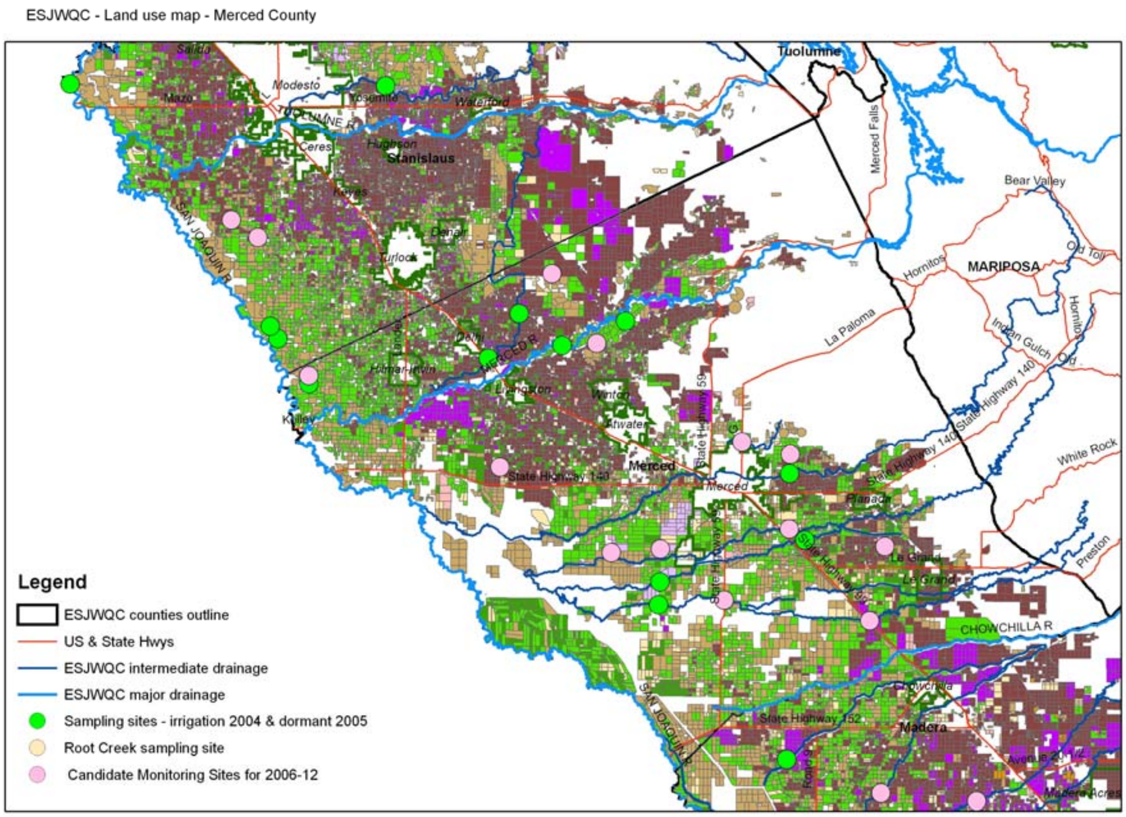


Figure 6. Land use for Madera County.

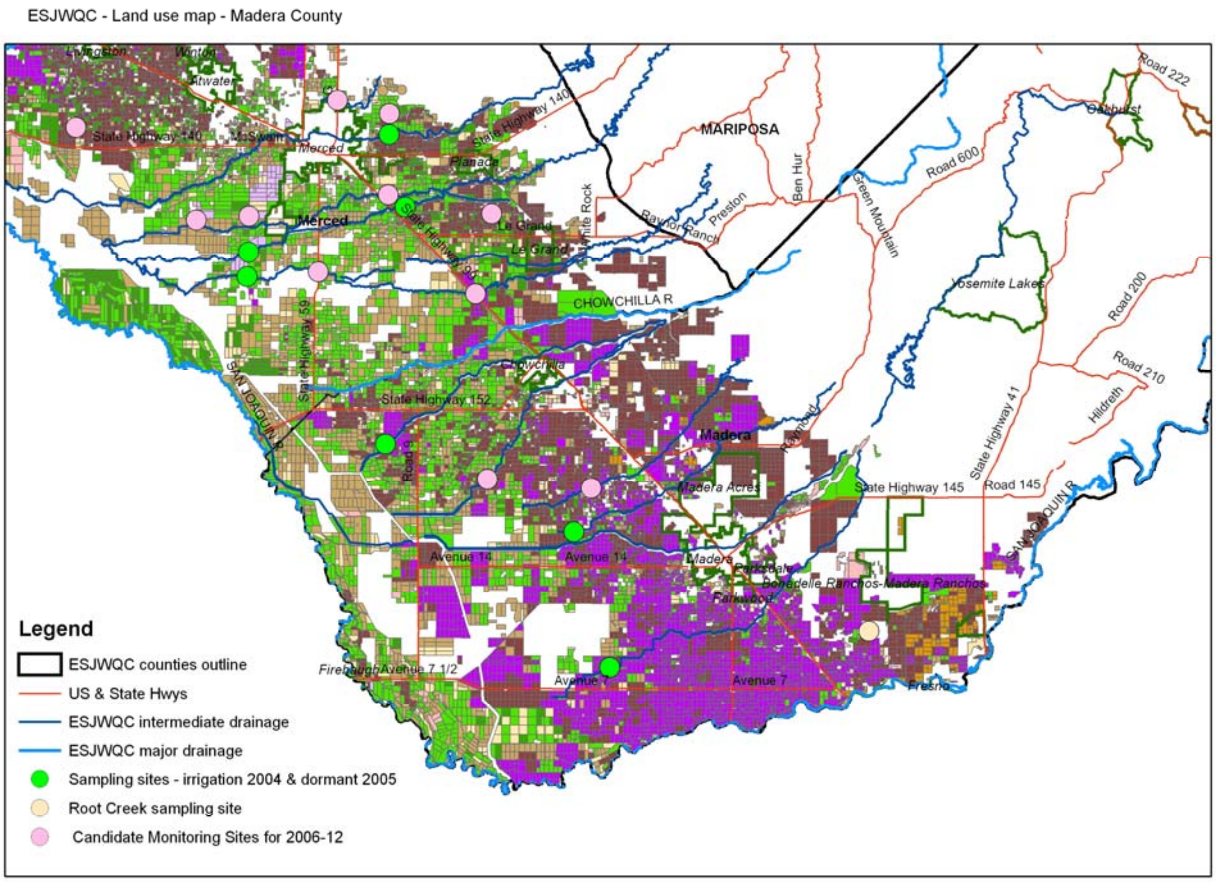


Figure 7. Land use for the upper Stanislaus River watershed in Calaveras County.

ESJWQC - Land use map - Calaveras County

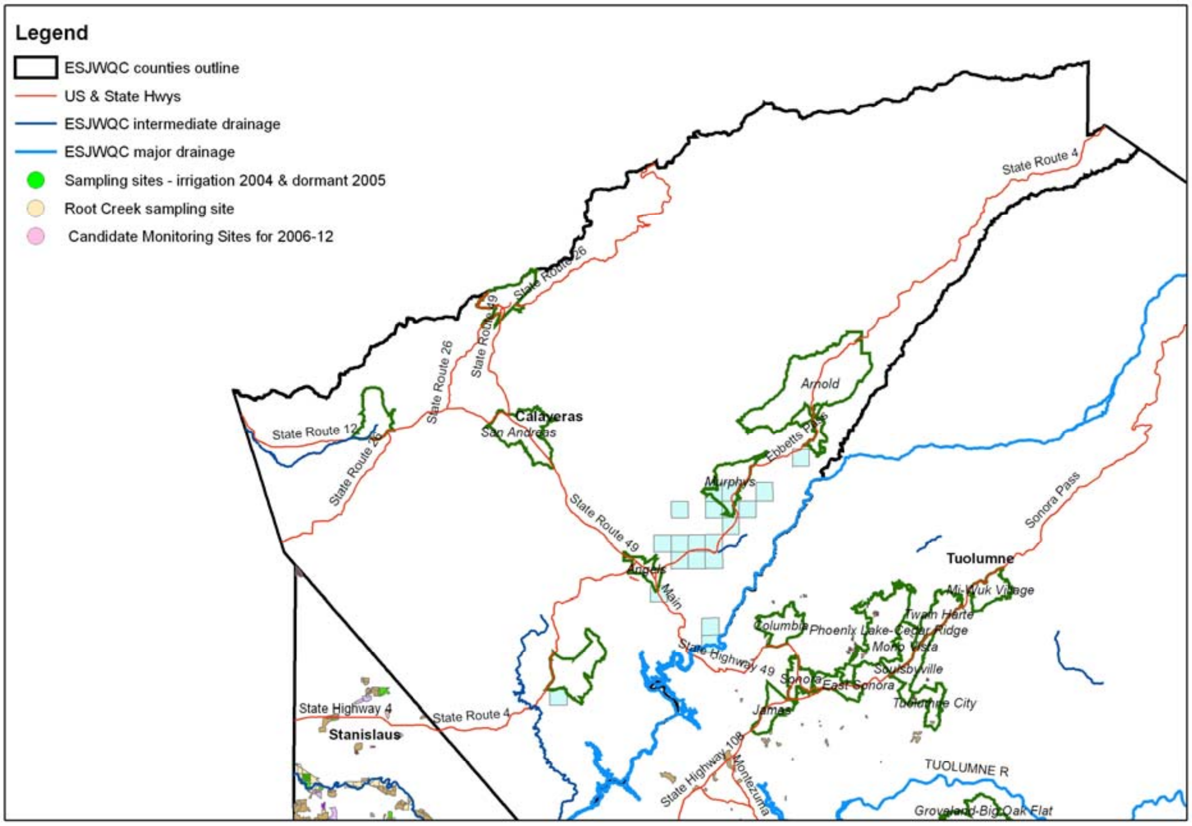


Figure 8. Land use for Tuolumne County. Because the parcels of irrigated agriculture are so small, they are almost impossible to see against the non-irrigated land within the county.

ESJWQC - Land use map - Tuolumne County

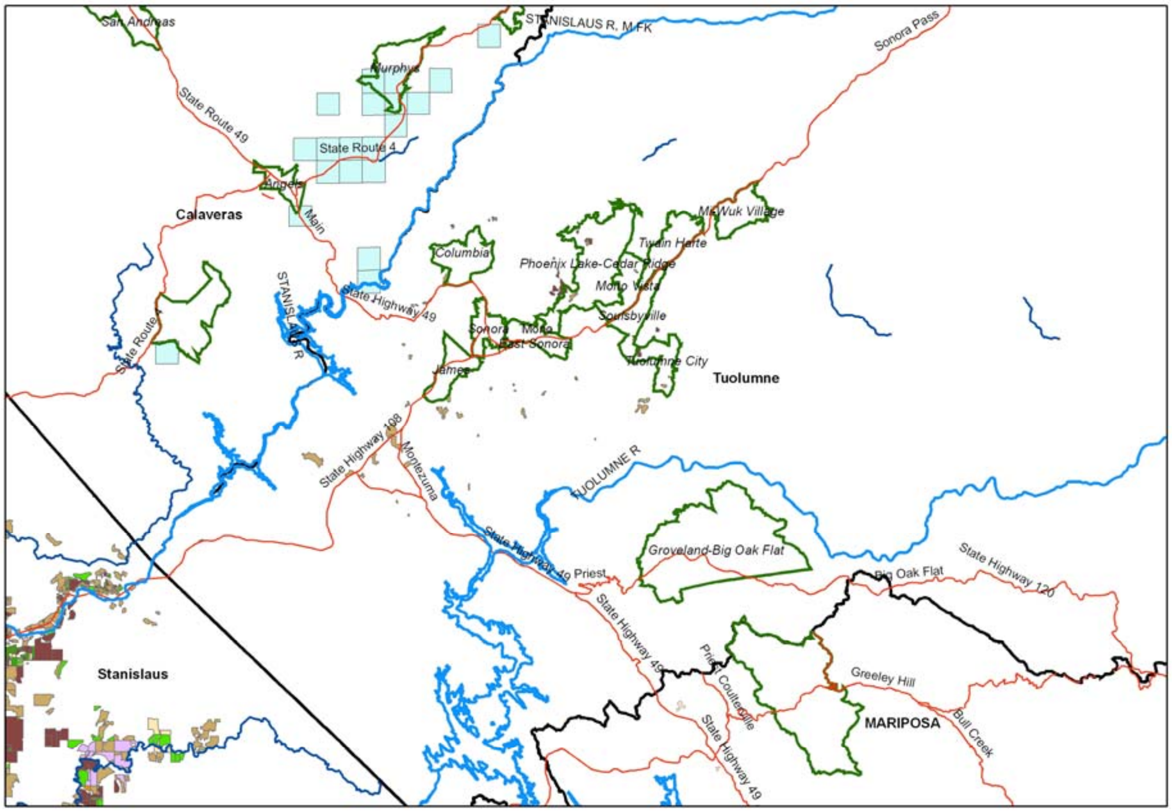


Figure 9. Land use for Mariposa County. Because the parcels of irrigated agriculture are so small, they are almost impossible to see against the non-irrigated land within the county.

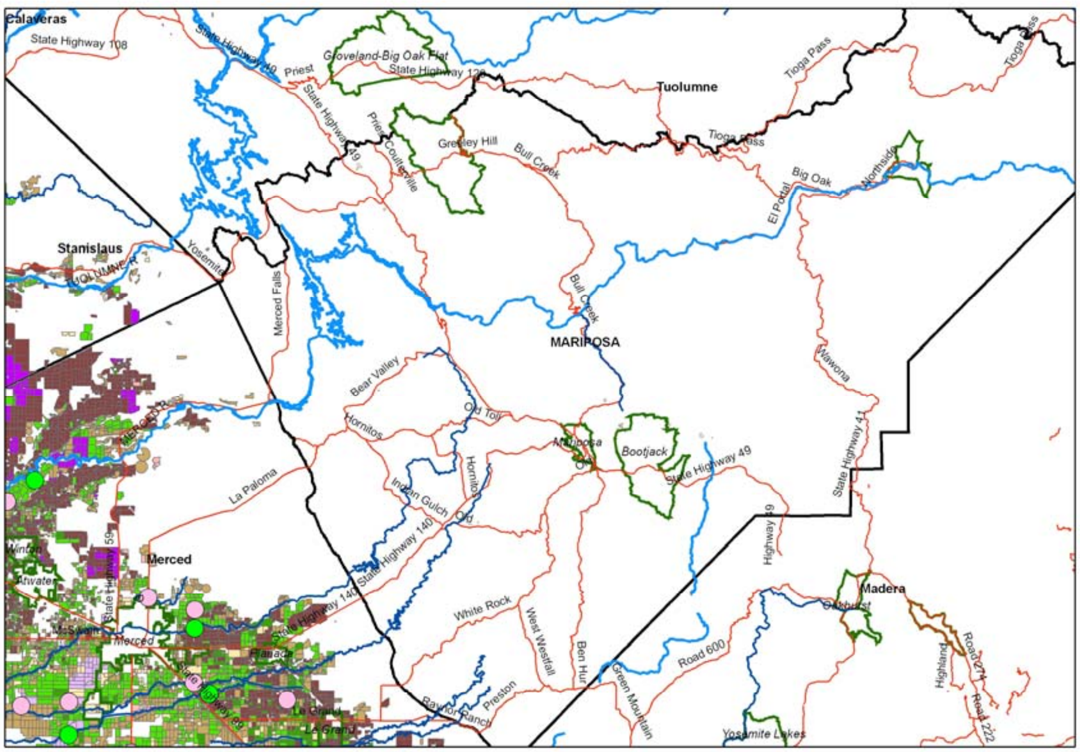


Table 2. Land use statistics for the upper Stanislaus drainage in Calaveras County, Mariposa and Tuolumne Counties.

	I/N	Mariposa County[1]	Tuolumne County[2]	Calaveras County - Stanislaus River watershed[3]
Citrus	I	9.4		
Deciduous nut and fruit	I	38.1	246.7	107.4
Deciduous nut and fruit	N	46.7	15.4	2.0
Field crop	I			2.0
Grain and hay	I			35.0
Grain and hay	N	14.1		
Idle	I			
Pasture	I			
Rice	I			
Truck, nursery, berry	I			
Riparian vegetation	N	344.1	654.7	
Wild vegetation	N	901,505.3	1,398,315.6	
Water surface	N	6,579.6	32,161.0	
Pasture	I	86.8	1,139.5	283.0
Pasture	N	3,278.8		
Rice	I			
Feedlot, dairy, farmstead	N	385.6	376.1	
Truck, nursery, berry	I		25.0	12.0
Urban	N	21,912.8	6,469.4	
Golf course, cemetery, landscape	N	419.9	487.6	
Vineyard	I	163.2	5.1	534.6
Total acres		934,784.3	1,439,896.1	
Irrigated acres		297.4	1,416.3	976.0

[1]Mariposa county land use information from DWR 1998 data
[2]Tuolumne county land use information from DWR 1997 data
[3]Calaveras County irrigated land information provided by Mary Mutz, Chief Deputy Agricultural Commissioner/Sealer (2005)

Table 3. Crops grown in Coalition Counties. Crop information was developed from Pesticide Use Reports from the 2004 DPR PUR database. An X in the month column specifying that there were pesticide use permits filed in those months indicating that applications of chemicals to those crops occurred.

COUNTY	Crop	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
CALAVERAS													
	APPLE			x			x						
	BLUEBERRY		x		x						x	x	
	CHERRY			x	x		x		x			x	
	GRAPES, WINE	x	x	x	x	x	x	x	x			x	x
	NECTARINE		x										
	N-OUTDR CONTAINER/FLD GRWN PLANTS		x	x	x	x	x	x		x			
	OATS, GENERAL	x	x	x									
	OLIVE (ALL OR UNSPEC)	x		x			x	x	x	x			x
	PASTURES (ALL OR UNSPEC)		x	x	x	x							
	PEACH		x										
	PISTACHIO (PISTACHE NUT)			x	x	x		x	x				
	VEGETABLES (ALL OR UNSPEC)			x									
	WALNUT (ENGLISH WALNUT, PERSIAN WALNUT)		x	x	x	x	x	x	x	x			
MADERA													
	ALFALFA (FORAGE - FODDER) (ALFALFA HAY)	x	x	x	x	x	x	x	x	x	x	x	x
	ALMOND	x	x	x	x	x	x	x	x	x	x	x	x
	APPLE		x	x	x	x	x	x	x				
	APRICOT	x	x	x	x	x							x
	BARLEY (FORAGE - FODDER)	x	x	x									
	BARLEY, GENERAL	x	x	x									
	BEANS (ALL OR UNSPEC)						x	x	x				
	BEANS, DRIED-TYPE	x					x	x	x				
	BLUEBERRY											x	
	BOYSENBERRY (BOYSENS)												x
	CARROTS, GENERAL		x	x		x	x	x					

CHERRY	x	x	x	x	x	x	x			x	x	x
CHRISTMAS TREE PLANTATIONS					x							
CITRUS FRUITS (ALL OR UNSPEC)		x			x		x		x		x	
CORN (FORAGE - FODDER)			x	x	x	x	x	x	x		x	
CORN, HUMAN CONSUMPTION		x	x		x	x	x					
COTTON, GENERAL	x	x	x	x	x	x	x	x	x	x	x	x
FIG	x	x	x	x	x	x	x	x	x		x	x
GARLIC	x		x	x	x							
GRAPES	x	x	x	x	x	x	x	x	x	x	x	x
GRAPES, WINE	x	x	x	x	x	x	x	x	x	x	x	x
KIWI FRUIT	x	x	x		x		x	x	x			
MELONS			x									
NECTARINE	x	x	x	x	x	x	x	x	x	x	x	x
N-GRNHS GRWN CUT FLWRS OR GREENS	x	x	x	x	x	x	x	x	x	x	x	x
N-GRNHS GRWN PLANTS IN CONTAINERS						x				x		
N-OUTDR CONTAINER/FLD GRWN PLANTS	x	x	x		x	x	x	x	x	x	x	x
N-OUTDR GRWN TRNSPLNT/PRPGTV MTRL		x	x	x	x	x	x	x	x			
OATS (FORAGE - FODDER)	x	x	x									x
OATS, GENERAL	x	x	x									x
OLIVE (ALL OR UNSPEC)	x	x	x		x	x	x	x	x	x	x	x
ONION (DRY, SPANISH, WHITE, YELLOW, RED, ETC.)			x	x						x	x	
ORANGE (ALL OR UNSPEC)	x	x	x	x	x	x	x	x	x	x	x	x
PASTURES (ALL OR UNSPEC)		x	x								x	x
PEACH	x	x	x	x	x	x	x	x	x	x	x	x
PEAR	x		x				x				x	
PECAN			x		x		x				x	
PERSIMMON			x		x		x	x	x			
PISTACHIO (PISTACHE NUT)	x	x	x	x	x	x	x	x	x	x	x	x
PLUM (INCLUDES WILD PLUMS FOR HUMAN CONSUMPTION)	x	x	x	x	x	x	x	x	x	x	x	x
POMEGRANATE (MISCELLANEOUS FRUIT)				x	x		x	x	x			x
PRUNE	x	x	x	x	x	x	x		x	x		x
SOIL APPLICATION, PREPLANT-OUTDOOR (SEEDBEDS,ETC.)	x	x	x	x	x	x		x	x	x	x	x
STONE FRUITS (ALL OR UNSPEC)		x							x			

	STRAWBERRY (ALL OR UNSPEC)	x			x							x	
	SUGARBEET, GENERAL	x		x	x	x	x	x	x	x			x
	TANGELO		x	x	x	x	x	x	x	x	x	x	x
	TANGERINE (MANDARIN, SATSUMA, MURCOTT, ETC.)			x	x	x		x		x	x	x	
	TOMATO			x				x	x	x	x		
	TOMATOES, FOR PROCESSING/CANNING	x		x	x	x	x	x	x		x	x	
	UNCULTIVATED AGRICULTURAL AREAS (ALL OR UNSPEC)	x	x	x	x	x	x	x	x		x	x	x
	WALNUT (ENGLISH WALNUT, PERSIAN WALNUT)	x	x	x	x	x	x	x	x	x		x	
	WATERMELONS					x							
	WHEAT (FORAGE - FODDER)	x	x	x			x	x	x	x			x
	WHEAT, GENERAL	x	x	x	x							x	x
MARIPOSA													
	APPLE			x	x	x							
	GRAPES, WINE		x	x	x	x	x	x	x				
	N-OUTDR CONTAINER/FLD GRWN PLANTS	x	x	x	x	x	x	x	x	x	x	x	x
MERCED													
	ALFALFA (FORAGE - FODDER) (ALFALFA HAY)	x	x	x	x	x	x	x	x	x	x	x	x
	ALMOND	x	x	x	x	x	x	x	x	x	x	x	x
	APPLE	x						x					x
	APRICOT	x	x	x	x	x	x	x	x		x		
	ASPARAGUS (SPEARS, FERNS, ETC.)				x			x	x		x		
	BARLEY (FORAGE - FODDER)												x
	BARLEY, GENERAL	x	x	x									x
	BEANS, DRIED-TYPE		x		x	x	x	x	x	x	x		
	BEANS, SUCCULENT (OTHER THAN LIMA)				x	x	x	x	x	x	x		
	BLUEBERRY		x	x	x		x	x			x	x	
	BOYSENBERRY (BOYSENS)				x		x						
	BROCCOLI										x	x	
	CANTALOUPE			x		x	x	x	x	x		x	x
	CAULIFLOWER							x	x	x			
	CHERRY	x	x	x	x	x		x				x	x
	CHICORY (ALL OR UNSPEC)				x				x	x	x		
	CHINESE CABBAGE (NAPPA, WON BOK, CELERY CABBAGE)				x						x		

CHINESE GREENS, CHINESE LEAFY VEGETABLES					x							
CHRISTMAS TREE PLANTATIONS	x	x					x					
CITRUS FRUITS (ALL OR UNSPEC)	x				x							x
COLE CROPS (ALL OR UNSPEC)												x
CORN (FORAGE - FODDER)	x	x	x	x	x	x	x	x	x	x	x	x
CORN, HUMAN CONSUMPTION	x	x	x	x	x	x	x	x	x			x
COTTON, GENERAL	x	x	x	x	x	x	x	x	x	x	x	x
CUCUMBER (PICKLING, CHINESE, ETC.)	x			x				x	x			
FIG		x	x	x	x	x	x	x	x		x	x
FORAGE - FODDER GRASSES (ALL OR UNSPEC) (HAY)	x	x	x									
GRAPES		x	x	x	x	x	x					
GRAPES, WINE	x	x	x	x	x	x	x	x	x	x	x	x
LEAFY VEGETABLES (ALL OR UNSPEC)								x	x	x	x	
LETTUCE, HEAD (ALL OR UNSPEC)				x								
MELONS							x	x				
MUSTARD, GENERAL									x			
NECTARINE	x	x	x	x	x	x	x				x	
N-GRNHS GRWN PLANTS IN CONTAINERS	x	x	x	x	x	x	x	x	x	x		
N-OUTDR CONTAINER/FLD GRWN PLANTS	x	x	x	x	x	x	x	x	x	x	x	x
N-OUTDR GRWN TRNSPLNT/PRPGTV MTRL	x	x	x	x	x	x	x	x		x	x	x
OATS (FORAGE - FODDER)	x	x	x	x	x			x	x		x	x
OATS, GENERAL	x	x	x								x	
OLIVE (ALL OR UNSPEC)											x	
ONION (DRY, SPANISH, WHITE, YELLOW, RED, ETC.)		x	x	x	x						x	x
ORNAMENTAL TURF (ALL OR UNSPEC)	x	x	x	x		x	x	x	x		x	
PASTURES (ALL OR UNSPEC)	x	x	x	x	x	x	x	x		x		
PEACH	x	x	x	x	x	x	x	x	x	x	x	x
PEAR	x			x		x	x					
PEAS, GENERAL	x	x	x									
PECAN					x	x	x		x			
PEPPERS (CHILI TYPE) (FLAVORING AND SPICE CROP)			x	x	x		x	x	x	x	x	
PEPPERS (FRUITING VEGETABLE), (BELL, CHILI, ETC.)	x		x	x	x	x	x	x	x	x		
PISTACHIO (PISTACHE NUT)	x	x	x	x	x	x	x	x	x	x	x	x

	PLUM (INCLUDES WILD PLUMS FOR HUMAN CONSUMPTION)	x	x	x	x	x		x	x	x		x	x
	PRUNE	x	x	x		x	x	x	x	x			x
	PUMPKIN						x	x	x	x			
	RADISH					x		x					
	RICE (ALL OR UNSPEC)					x	x	x	x				
	RYE (ALL OR UNSPEC)		x										
	SAFFLOWER, GENERAL	x											
	SOIL APPLICATION, PREPLANT-OUTDOOR (SEEDBEDS,ETC.)	x	x	x								x	x
	SORGHUM (FORAGE - FODDER) (SORGO, ETC.)						x		x	x			
	SQUASH (ALL OR UNSPEC)							x	x				
	SQUASH (WINTER) (HUBBARD SQUASH, CALABAZA, ETC.)							x	x	x			
	STONE FRUITS (ALL OR UNSPEC)			x									
	STRAWBERRY (ALL OR UNSPEC)	x	x	x	x		x	x	x				x
	SUDANGRASS (FORAGE - FODDER) (SORGHUM SUDANESE)					x	x	x	x	x			
	SUGARBEET, GENERAL	x	x	x	x	x	x	x	x	x	x		
	SWEET POTATO	x	x	x	x	x	x	x	x	x		x	x
	TOMATILLO						x	x					
	TOMATO	x	x	x	x	x	x	x	x	x	x	x	x
	TOMATOES, FOR PROCESSING/CANNING	x	x	x	x	x	x	x	x	x	x	x	x
	UNCULTIVATED AGRICULTURAL AREAS (ALL OR UNSPEC)	x	x	x	x					x	x	x	x
	WALNUT (ENGLISH WALNUT, PERSIAN WALNUT)	x	x	x	x	x	x	x	x	x	x	x	x
	WATERMELONS			x	x	x	x	x	x		x	x	
	WHEAT (FORAGE - FODDER)	x	x	x							x	x	x
	WHEAT, GENERAL	x	x	x	x		x			x		x	x
STANISLAUS													
	ALFALFA (FORAGE - FODDER) (ALFALFA HAY)	x	x	x	x	x	x	x	x	x	x	x	x
	ALMOND	x	x	x	x	x	x	x	x	x	x	x	x
	APPLE	x	x	x	x	x	x	x	x	x	x	x	x
	APRICOT	x	x	x	x	x	x	x	x	x	x	x	x
	ARRUGULA (ROQUETTE, ROCKET SALAD)							x					
	ASPARAGUS (SPEARS, FERNS, ETC.)						x		x				
	BARLEY (FORAGE - FODDER)		x										
	BARLEY, GENERAL										x		x

BASIL (BUSH, GARDEN, SWEET)		x	x	x	x	x	x	x	x	x	x	
BEANS, DRIED-TYPE	x	x	x	x	x	x	x	x	x	x	x	
BEANS, SUCCULENT (OTHER THAN LIMA)			x	x	x	x	x	x	x			
BEETS, GENERAL	x	x	x	x	x	x	x	x	x	x	x	x
BOK CHOY (WONG BOK)	x	x	x	x	x	x	x	x	x	x	x	x
BOYSENBERRY (BOYSENS)	x		x		x		x				x	
BROCCOLI	x		x	x	x	x	x	x	x	x	x	x
CABBAGE	x	x	x	x	x	x	x	x	x	x	x	x
CANTALOUPE			x		x	x	x	x	x			
CAULIFLOWER			x		x		x	x	x	x		
CELERIAC (CELERY ROOT)	x	x					x	x	x		x	
CELERY, GENERAL		x	x	x	x	x	x	x	x	x	x	x
CHERRY	x	x	x	x	x	x	x	x	x	x	x	x
CHESTNUT		x		x	x	x	x	x		x		x
CHICORY (ALL OR UNSPEC)	x							x	x	x	x	
CHINESE GREENS, CHINESE LEAFY VEGETABLES										x	x	
CHINESE RADISH/DAIKON (LOBOK, JAPANESE RADISH)	x	x	x	x	x	x	x	x	x	x	x	x
CILANTRO (CHINESE PARSLEY, CORIANDER LEAVES)	x	x	x	x	x	x	x	x	x	x	x	x
CITRUS FRUITS (ALL OR UNSPEC)		x	x	x	x	x	x	x		x	x	
COLLARDS	x	x	x	x	x	x	x	x	x	x	x	x
CORN (FORAGE - FODDER)		x	x	x	x	x	x	x	x	x		x
CORN, HUMAN CONSUMPTION						x	x				x	
COUNTY AG. COMM. SALES											x	
CUCUMBER (PICKLING, CHINESE, ETC.)			x	x	x	x	x	x				
DANDELION (CHINESE DANDELION, GOW GAY)	x	x	x	x	x	x	x	x	x	x	x	x
DILL	x	x	x	x	x	x	x	x	x			x
ENDIVE (ESCAROLE)	x								x		x	
FENNEL (ALL OR UNSPEC)		x	x	x	x	x	x	x	x			
FIG										x		
FLAVORING AND SPICE CROPS (ALL OR UNSPEC)				x		x		x		x		
FORAGE - FODDER GRASSES (ALL OR UNSPEC) (HAY)	x		x									
GRAPES	x		x	x	x	x	x	x		x	x	x
GRAPES, WINE	x	x	x	x	x	x	x	x	x	x	x	x

KALE	x	x	x	x	x	x	x	x	x	x	x	x
KIWI FRUIT		x	x		x			x	x			
KOHLRABI	x	x	x	x	x	x	x	x	x	x	x	x
LEEK			x	x	x	x	x	x	x	x	x	
LETTUCE, LEAF (ALL OR UNSPEC)	x	x	x	x	x	x	x	x	x	x	x	x
MELONS						x	x	x			x	
MINT (ALL OR UNSPEC)	x		x	x	x	x	x	x	x	x	x	
MUSTARD, GENERAL	x	x	x	x	x	x	x	x	x	x	x	x
NECTARINE	x	x	x	x	x	x	x		x	x	x	x
N-GRNHS GRWN PLANTS IN CONTAINERS	x	x	x	x	x	x	x	x	x	x	x	x
N-GRNHS GRWN TRNSPLNT/PRPGTV MTRL	x	x	x	x	x	x	x	x	x			
N-OUTDR CONTAINER/FLD GRWN PLANTS	x	x	x	x	x	x	x	x	x	x	x	x
N-OUTDR GRWN CUT FLWRS OR GREENS												x
N-OUTDR GRWN TRNSPLNT/PRPGTV MTRL	x	x	x	x	x	x	x	x	x	x	x	x
OATS (FORAGE - FODDER)	x	x	x	x		x	x			x	x	x
OATS, GENERAL		x	x									
OLIVE (ALL OR UNSPEC)					x	x	x	x	x			
ORNAMENTAL TURF (ALL OR UNSPEC)	x	x	x	x	x	x	x	x	x			
PARSLEY (LEAFY VEGETABLE)	x	x	x	x	x	x	x	x	x	x	x	x
PASTURES (ALL OR UNSPEC)	x	x	x	x	x	x	x	x	x	x		x
PEACH	x	x	x	x	x	x	x	x	x	x	x	x
PEAR		x					x			x	x	x
PEAS, GENERAL	x	x	x									
PECAN			x	x	x		x					x
PEPPERS (FRUITING VEGETABLE), (BELL,CHILI, ETC.)	x		x	x	x							
PERSIMMON		x	x		x		x			x		
PISTACHIO (PISTACHE NUT)	x	x		x	x	x	x	x				x
PLUM (INCLUDES WILD PLUMS FOR HUMAN CONSUMPTION)	x	x	x	x	x	x	x	x		x	x	x
POMEGRANATE (MISCELLANEOUS FRUIT)							x			x		
PRUNE	x	x									x	x
PUMPKIN						x	x	x	x			
QUINCE											x	
RICE (ALL OR UNSPEC)			x	x	x	x	x					

	RYE (ALL OR UNSPEC)		x										
	RYEGRASS, PERENNIAL (FORAGE - FODDER)		x										
	SOIL APPLICATION, PREPLANT-OUTDOOR (SEEDBEDS,ETC.)		x										
	SORGHUM (FORAGE - FODDER) (SORGO, ETC.)								x				
	SPINACH	x	x	x	x	x	x	x	x	x	x	x	x
	STRAWBERRY (ALL OR UNSPEC)		x	x	x			x	x	x			x
	SUDANGRASS (FORAGE - FODDER) (SORGHUM SUDANESE)							x	x				
	SUGARBEET, GENERAL			x	x	x	x		x	x			
	SWEET POTATO	x		x	x	x							x
	SWISS CHARD (SPINACH BEET)	x	x	x	x	x	x	x	x	x	x	x	x
	TOMATO				x	x	x	x	x	x	x	x	
	TOMATOES, FOR PROCESSING/CANNING	x	x	x	x	x	x	x	x	x	x		x
	TURNIP, GENERAL	x	x	x	x	x	x	x	x	x	x	x	x
	WALNUT (ENGLISH WALNUT, PERSIAN WALNUT)	x	x	x	x	x	x	x	x	x	x	x	x
	WATERMELONS				x	x	x	x	x	x			
	WHEAT (FORAGE - FODDER)	x	x	x	x							x	x
	WHEAT, GENERAL	x	x	x	x								
TUOLUMNE													
	APPLE		x	x	x	x	x	x					
	BLACKBERRY				x								
	BOYSENBERRY (BOYSENS)		x	x	x								
	CHERRY		x	x	x								
	GRAPES						x						
	GRAPES, WINE					x							
	NECTARINE				x								
	N-OUTDR CONTAINER/FLD GRWN PLANTS	x	x	x	x	x	x						
	N-OUTDR GRWN CUT FLWRS OR GREENS			x			x						
	PASTURES (ALL OR UNSPEC)			x	x	x	x	x					
	PEACH		x	x		x	x						
	PEAR		x	x	x		x						

Climate

Summer temperatures are usually hot in the valley, ranging from the mid 80's to mid 90's (^{o}F) for average high temperatures and the mid to upper 50's for average summer low temperatures. In the summer the northern area is subject to pulses of cool coastal air that can provide relief from summertime highs and allow for the farming of crops requiring cooler temperatures. The upland areas are slightly cooler at night but generally remain hot throughout the summer. In the winter, temperatures are usually moderate in the valley with average high temperatures in the mid to upper 50's and average low temperatures in the low 40's. Freezing is common; this generally prevents farming of perennial crops susceptible to frost. Annual precipitation on the valley floor in the Coalition area is variable, averaging 13-15 inches per year (City of Merced). Rainfall occurs predominantly during the winter and is heterogeneously distributed throughout this period (typical for a Mediterranean climate). Winter seasons are characterized by several small storms with one or two major events (increased rain due to several larger storms) providing the bulk of the precipitation. December, January and February are historically the months with greatest precipitation. There appears to be no discernible pattern as to when during the winter these large storms occur.

Soils

Soils maps reveal a complicated mosaic of soil types in the Coalition area. Generally, the Coalition area has sandy, well-drained soils. Exceptions to this are soils in the immediate proximity to the SJR that contain more clay and thus do not drain well. These areas are more likely to require surface drains to remove water during periods of high rainfall and occasionally during the irrigation season. Soil type combines with other factors such as slope, soil saturation, rainfall/irrigation water amount, and drainage patterns to control runoff. Soils maps and ArcGIS soils coverages have been delivered to the CVRWQCB previously and will not be provided as part of this document.

Hydrology

As indicated above, there are several main rivers that cross the Coalition area from east to west. These rivers have complex hydrologic systems due to both seasonal influence of precipitation, and management systems for water use (reservoirs, basin transfers, hydropower, municipal and irrigation supply, and anadromous fisheries). In general flows are greatest during the winter and spring due to wintertime precipitation and subsequent springtime snowmelt. Summertime flows are now greater than historically due to reservoir releases during this period. The numerous small creeks that have their headwaters in the foothills and western portion of the Sierra Nevada mountain range are primarily ephemeral with no flow from early summer through the first rains of the winter. Later discussion of hydrology will be specific to each subwatershed.

There is an increased propensity for runoff with increased slope, soil water saturation, and volume of water, conditions that arise primarily due to large amounts of rainfall and are more likely in the relatively greater sloped valley margins. During the winter, runoff is drained through the myriad of creeks, rivers and drains for flood management and may be subject to efforts of larger geographic flood control programs. Runoff can also occur during the irrigation season if water entering the field is greater than the amount that can infiltrate the soil. Recent sampling efforts indicate that many of the drainages in the southern portion of the Coalition region do not always carry runoff even during substantial rainfall events. Immediately after a storm in March of 2005, Ash Slough did not maintain sufficient flows to be sampled even when adjacent orchards were flooded. Also, the watersheds throughout the Coalition region tend to be "flashy" in that water from runoff events moves through the systems very quickly leaving very little flow shortly after the storm ends. For example, there was no flow remaining when crews visited the site for persistence sampling in the Lone Willow Slough watershed approximately a week after a winter 2005 storm event.

A complex system for water transfer, use, and re-use is utilized for irrigation purposes. Without precise methods of applying water for irrigation purposes some water may return to the source after being used on the field. In some cases, the volume of water applied to a field for irrigation may represent not only what is needed by the vegetative crop, but also a greater quantity used either to push the water over the field, or as a method of reducing the negative effects of evapotranspiration and consequent accumulation of salts. The system is designed to allow downstream irrigators to reuse the same water that was previously used upstream.

Valuable Aquatic Resources

Aquatic resources for water bodies within the Coalition area have been defined in part as those assigned as beneficial use (BU) by the water board. Using the tributary rule, BUs were applied to tributaries based on the currently assigned BU (Table 4) in downstream water bodies. Important aquatic resources exist in the Coalition area, including municipal and agricultural water use, cold water and warm water stream aquatic habitat, wetlands and fisheries resources.

Wetlands are an important aquatic resource within the Coalition area. These habitats are associated with riparian areas along many of the water bodies in the region (particularly in the Sandy Mush Country area of southern Merced County) and savannah step region of the lower Sierra Foothills. Because vernal pools are isolated mini-watersheds they are found heterogeneously distributed across the Coalition in upland areas. They receive winter rains and require an aquatard to maintain their characteristic pools into the spring. These wetlands maintain a unique flora and fauna and are protected by the Clean Water Act, yet they are not considered to be a focal point of the Phase I Agricultural Waiver Monitoring and Reporting Program Plan. Generally, vernal pools and irrigated agriculture are not found together, although there are exceptions.

Several fisheries are considered important in the Coalition area. Steelhead trout (*Oncorhynchus mykiss*) were common in the region prior to the building of the dams on all of the major tributaries of the San Joaquin River. Once the dams were built, historic spawning grounds were eliminated and with them, most of the wild salmonids in the San Joaquin Valley. Currently, no permanent steelhead stocks exist in the drainages of the San Joaquin Valley despite occasional reports of fish in the Tuolumne and Merced Rivers. The California Department of Fish and Game considers the Tuolumne River to have suitable habitat to support a steelhead run if one could become established.

Chinook salmon (*Oncorhynchus tshawytscha*) are present in the San Joaquin system and are found in all major tributaries in the region. All of the major tributaries are considered to be impaired for salmonid spawning and/or migration habitat as is the main stem of the San Joaquin River (Table II-1 of the Sacramento/San Joaquin River Basin Plan).

Table 4. Major river to which each subwatershed drains to, and the beneficial use for each of the major river reaches.

Subwatershed	Immediate Downstream River	Beneficial Use of Immediate Downstream River *
Cottonwood Creek @ Road 20** Root Creek ** Cottonwood Creek @ Sixmile road	San Joaquin River[1]	1-4, 7-15
Ash Slough @ Avenue 21** Bear Creek @ Kibby Rd** Dry Creek @ Road 18** Duck Slough @ Gurr Road Duck Slough @ Pioneer Road Mattos Drain @ Range Road Black Rascal Creek @ Kibby road Berenda Slough @ Dairyland Road Mariposa Creek @ Simonson Way Deane Drain @ Gurr Road Owens Creek @ Kibby Road Dutchman Creek @ Highway 99 Berenda Creek @ Road 19** Deadman Creek @ Highway 59 Livingston Drain @ Robin Ave	San Joaquin River[2]	1-4, 7-9, 11-15
Mustang Creek @ East Ave Highline Canal @ Hwy 99 Highline Canal @ Lombardy Ave Hilmar Drain @ Central Ave Cavill Drain @ McGee Road Prairie Flower Drain @ Crows Landing Rd. Hatch Drain @ Monte Vista Ave Western States Drain @ Central Ave Westport Drain @ Vivian Road	San Joaquin River[3]	1-4, 7-9, 11-13, 15
Dry Creek @ Wellsford Road	Tuolumne River[4]	1-3, 7-10, 12-15
Jones Drain @ Oakdale Road Merced River @ Santa Fe Silva Drain @ Meadow Drive	Merced River[5]	1, 3-15

1 Friant Dam to Mendota Pool reach
2 Sack Dam to Merced River reach (all waterbodies that drain to this reach enter via the East Side Bypass with the exception of Livingston Drain)
3 Merced River to Delta reach
4 New Don Pedro Reservoir to San Joaquin River reach
5 McSwain Reservoir to San Joaquin River reach

* See below for Beneficial Use code list.

** Surface water flow in these waterbodies terminates in subterranean flow except for periods of increased runoff during large winter storms.

Beneficial uses
Municipal and Domestic Supply – 1
Agriculture Supply (irrigation) – 2
Agriculture Supply (stock watering) – 3
Industrial Process Supply – 4
Industrial Service Supply – 5
Hydropower Generation – 6
Water Contact Recreation – 7
Non-contact Water Recreation – 8
Warm Freshwater Habitat – 9
Cold Freshwater Habitat – 10
Migration of Aquatic Organisms (warm) – 11
Migration of Aquatic Organisms (cold) – 12
Spawning, Reproduction, and/or Early Development (warm) – 13
Spawning, Reproduction, and/or Early Development (cold) – 14
Wildlife Habitat – 15

Subwatersheds

There are 32 subwatersheds in the Coalition area that are classified by three types (large, intermediate or small) based on water flow and watershed size (Figures 2, Table 5). The large watersheds within the Coalition area are the five major rivers (Chowchilla River, Fresno River, Merced River, Tuolumne River and Stanislaus River). With the exception of the Merced River, none of the large rivers are sampled. The Merced River is sampled but relatively high in the watershed to allow the integration of the sampling results from smaller water bodies (e.g., Jones Drain) that drain into the river upstream. Though the irrigated agriculture area within these watersheds is similar or even less than some of the watersheds classified as medium sized, water flow in these relatively larger watersheds is primarily a function of source water originating upstream of irrigated agriculture. These rivers have relatively greater base water flow due to snowmelt and reservoir releases. There are 15 intermediate sized subwatersheds in the Coalition Region (see Table 3 for listing). These are primarily natural creeks and sloughs that drain a large portion of the Coalition area. The 16 smaller watersheds in the Coalition area are either small-sized natural creeks, or agriculture canals and drains (see Table 5).

The Coalition currently samples 9 of the 15 intermediate sized drainages. We will add a 10^{th} intermediate sized drainage in April 2006. Beginning in the irrigation season 2006, the Coalition will sample 67% of its intermediate sized drains, ahead of the 40% required by the MRP. By the irrigation season 2006, 59% of all watersheds identified for sampling will be in the monitoring program in either Phase 1 or Phase 2 sampling.

In addition to the monitoring sites established by the ESJWQC, we will be able to obtain data from the East San Joaquin Water Quality Framework from the sampling of their operational spill sites. These sites increase the geographic coverage within the Coalition region.

Table 5. Subwatersheds within the ESJWQC area, type (Large, Intermediate, Small) and total watershed size. The subwatershed is formed from the location of the sample site (or proposed sample site, see MRPP), not the location where the watershed has its confluence with a downstream water body. Also, some watersheds do not connect to downstream water bodies. See Table 2 for a list.

Subwatershed	Type	Watershed Size (irrigated acres)
Ash Slough @ Avenue 21	I	21,015
Bear Creek @ Kibby Rd	I	6,279
Cottonwood Creek @ Road 20	I	113,424
Dry Creek @ Road 18	I	15,448
Dry Creek @ Wellsford Road	I	12,110
Duck Slough @ Gurr Road	I	17,116
Duck Slough @ Pioneer Road	I	6,895
Highline Canal @ Hwy 99	I	14,585
Highline Canal @ Lombardy Ave	I	9,196
Hilmar Drain @ Central Ave	S	1,658
Jones Drain @ Oakdale Road	S	2,140
Merced River @ Santa Fe	L	23,402
Prairie Flower Drain @ Crows Landing Road	S	2,610
Owens Creek @ Kibby Road	S	4,828
Silva Drain @ Meadow Drive	S	476
Mustang Creek @ East Ave	I	12,400
Mattos Drain @ Range Road	S	1,130
Black Rascal Creek @ Kibby road	S	1,406
Berenda Slough @ Dairyland Road	I	19,834
Mariposa Creek @ Simonson Way	S	496
Deane Drain @ Gurr Road	S	4,701
Cavill Drain @ McGee Road	S	13,751
Dutchman Creek @ Highway 99	I	8,734
Dutchman Creek (Deadman Creek) @ Gurr Road	I	25,626
Cottonwood Creek @ Sixmile road	S	442
Hatch Drain @ Monte Vista Ave	S	1,411
Berenda Creek @ Road 19	I	16,789
Deadman Creek @ Highway 59	I	22,354
Livingston Drain @ Robin Ave	S	2,418
Western States Drain @ Central Ave	S	6,109
Westport Drain @ Vivian Road	S	755
Root Creek	S	8,378[1]

[1]Watershed documents have been requested from the Root Creek Coalition to determine if our estimates of area are similar to theirs. At this time, the total acreage for the Root Creek watershed is an estimate.

Narrative Description of subwatersheds within the Coalition region

All subwatersheds in Tables 6 - 11 drain agricultural land in the Coalition region. The discussion below briefly describes each subwatershed with respect to hydrology and agricultural production. Maps for sites monitored during the dormant season and the 2005 irrigation season were provided in East San Joaquin Water Quality Coalition Semi-Annual Report of Monitoring and Outreach Activities, January 6, 2006. The maps provided as Figures 10-14 provide more detail on the crops grown on each of the parcels in the subwatershed and the hydrology within the subwatershed that drains through those parcels in sites to be monitored starting in the 2006 irrigation season.. ArcGIS coverage of all subwatersheds will be provided electronically along with this report. Not included are roadside ditches that may drain fields to the nearest surface water body. Ditches are constructed to move water draining from roads adjacent to the fields and are not generally constructed to move water draining from agricultural fields. Ditches are more common in the northern portion of the Coalition region where soils are somewhat more resistant to infiltration. In the southern portions of the Coalition region (e.g., southern Merced and Madera Counties), sandy soils with a high infiltration rate do not require ditches to move water that has drained from the road surfaces. Detail descriptions of the crops in each watershed are provided in Tables 6 – 11.

Sites monitored through the 2006 winter storm water runoff season.

Highline Canal @ Lombardy Road (9,196 irrigated acres) – The Highline Canal is a conveyance of the Turlock Irrigation District and carries both clean irrigation water and irrigation return flow. The main upstream tributary of the Highline Canal is Mustang Creek. The Highline Canal flows west and eventually drains into the Merced River. Dairies are present upstream and the Mustang Creek, a major tributary during the dormant season, passes immediately to the southeast of the Turlock Airport. The main agricultural crop upstream is deciduous nuts (Table 8).

Duck Slough @ Gurr Road (17,116 irrigated acres) – This site is currently monitored and is proposed to be a core site. Located to the south and west of Merced, the site drains field crops immediately upstream and deciduous nuts farther upstream (Table 6). In addition, there is irrigated pasture upstream. We have recently learned that the city of Merced delivers treated water to Duck Slough a few miles upstream of the Gurr Road site. Duck Slough drains west flows eventually becoming Deadman Creek in the western portion of the coalition region. It continues to flow west feeding with a series of duck ponds near the Eastside Bypass and eventually drains into Deep Slough.

Merced River @ Santa Fe (23,402 irrigated acres) – This water body is designated as a major water body and is 303d listed. It was selected as an integrator site for several of the drains and tributaries in the vicinity. The Merced River originates in the high Sierra and flows through the Sierra’s encountering several dams and impoundments. The Merced River eventually drains into the San Joaquin River near Hatfield State Park. Upstream agriculture includes some field crops in the immediate vicinity of the river and deciduous nuts, primarily almonds (Table 8).

Dry Creek @ Wellsford Road (12,110 irrigated acres) – This site is in the northern part of the Coalition region and drains a combination of field crops, deciduous nuts, and vineyards (Table 7). Dry Creek drains into the Tuolumne River in Modesto and this site represents the closest accessible location to Modesto that collects agricultural drainage. There appear to be dairies upstream and the town of Waterford may provide some urban signal but the site appears to be sufficiently far from Waterford to be used as a core site.

Ash Slough @ Avenue 21 (21,015 irrigated acres) – This site was used as a monitoring station during the 2004 irrigation season, although lack of flow did not allow samples to be collected. Agriculture upstream includes vineyards, field crops, and deciduous nuts (Table 7). Ash Creek flows just north of Chowchilla but there appears to be a buffer of agricultural land between Ash Slough and Chowchilla. As is true with most sites, there are dairies located upstream.

Prairie Flower Drain @ Crows Landing Road (2,610 irrigated acres) – Several drains exist in the western portion of the Coalition region and we are proposing Prairie Flower Drain as a core monitoring site. Relative to other drains in this part of the Coalition region, Prairie Flower Drain is longer and appears to drain a larger number of parcels of irrigated agriculture (Table 8). Dairies and feedlots are ubiquitous in this part of the Coalition region and this drain may receive runoff from several dairies immediately upstream. Upstream agriculture is field crops.

Cottonwood Creek @ Road 20 (113,424 irrigated acres) – This site is at the very southern edge of the Coalition region in Madera County and the creek drains into the Eastside Bypass (Table 7). The immediate upstream agriculture is vineyards and there are deciduous nuts farther to the east. Unlike other sites, there are few dairies on Cottonwood Creek.

Bear Creek @ Kibby Road (6,279 irrigated acres) – This watershed drains an eastern portion of the coalition region in Merced County. Bear Creek originates in the foothills of the Sierra's with Burn's Creek as one of the major tributaries. The Creek drains to the east just north of the towns of Planada, and eventually flows through Merced and eventually to the San Joaquin River. The primary irrigated agriculture in the watershed includes deciduous nuts, field crops, truck crops, and irrigated pasture (Table 7).

Duck Slough @ Pioneer Road (6,895 irrigated acres) – This site is located upstream of the Duck Slough @ Gurr Road site and was selected to determine relative contribution of water quality impairments in the upstream portion of the Duck Slough watershed. Duck Slough originates in the Sierra foothills and flows west eventually joining with Deadman's Creek in the western portion of the coalition region. The Pioneer Road site is located just east of Highway 99 south of Planada and Merced. Irrigated agriculture in the watershed is primarily deciduous nuts, with truck crops and irrigated pasture the next most common land uses (Table 6).

Highline Canal @ Highway 99 (14,585 irrigated acres not including Highline Canal @ Lombardy Road watershed) – This site was selected as a downstream companion site to the Highline Canal @ Lombardy Road site. Selected for the same reason that the Duck Slough sites were selected, this site allows a determination of the relative contribution of the upstream and downstream watersheds to water quality impairments. The sampling site is located just south of Delhi as the canal crosses the highway. The irrigated agriculture is primarily deciduous nuts, and these are located at the lower end of the watershed. A small number of vineyards are also present (Table 6).

Hilmar Drain @ Central Ave (1,658 irrigated acres) – This site is located toward the western edge of the coalition region near the San Joaquin River. This is a small watershed that is primarily field crops. This watershed also contains a large number of dairies. Hilmar Drain originates at Williams Ave and Washington Road and eventually drains into the San Joaquin River. The primary irrigated agriculture is field crops and irrigated pasture (Table 6).

Jones Drain @ Oakdale Road (2,140 irrigated acres) – This is a small watershed with the primary irrigated agriculture being deciduous nuts, field crops, and irrigated pasture (Table 8). The Jones Drain is located just south of the Merced River and joins with the Silva Drain and both eventually drain into the Merced River just upstream of the Merced River @ Santa Fe monitoring site.

Dry Creek @ Road 18 (15,448 irrigated acres) – This site was selected for monitoring during the middle of the 2005 irrigation season as a replacement site for Lone Willow Slough. (We learned that growers in the Lone Willow Slough watershed had joined the Westside Coalition.) This Dry Creek originates in the Sierra foothills and flows to the north of the city of Madera eventually draining into the San Joaquin River. Deciduous crops are the primary irrigated agriculture in the upper portion of the watershed, and vineyards predominate in the lower portions of the watershed. There are field crops scattered throughout the watershed (Table 7).

Sites and watersheds to be added to the monitoring program in April 2006.

Dutchman Creek @ Highway 99 (8,737 irrigated acres) – This watershed is an upstream section of the Deadman/Dutchman Creek watershed. Dutchman Creek flows out of the Sierra foothills and joins Deadman Creek downstream. The majority of the agriculture is nut orchards (Table 11, Figure 13).

Silva Drain @ Meadow Drive (476 irrigated acres) – This is a very small watershed that joins with Jones Drain just upstream of the confluence of Jones Drain with the Merced River. The primary agriculture is citrus orchards, with small amounts of field crops and irrigated pasture (Table 9, Figure 12).

Mustang Creek @ East Ave (12,400 irrigated acres) – Mustang Creek forms the headwaters of the Highline Canal. Mustang Creek is ephemeral with flow primarily during winter runoff events. Summer flows are intermittent. Citrus is the main agriculture with smaller amounts of field crops and grains and hay (Table 10, Figure 12).

Mattos Drain @ Range Road (1,130 irrigated acres) – Mattos Drain is located west of the Deanne Drain watershed. The watershed is a small watershed that is composed of irrigated pasture and field crops. The drain eventually empties into Owen's Creek. (Table 9, Figure 13).

Black Rascal Creek @ Kibby Road (1,406 irrigated acres) – Black Rascal Creek is another creek that has its headwaters in the Sierra foothills. It is located just to the north of the Bear Creek watershed and to the east of the city of Merced. Citrus and field crops make up the majority of the agriculture in the watershed (Table 9, Figure 13).

Berenda Slough @ Dairyland Road (19,834 irrigated acres) – Berenda Slough flows through the northern portion of Madera County and empties into the Eastside Bypass. The primary agriculture in the watershed is orchards and vineyards with small amounts of pasture and field crops (Table 11, Figure 14).

Sites and watersheds to be added to the monitoring program in the next years

Mariposa Creek @ Simonson Way (496 irrigated acres) – This is another very small watershed in which the irrigated agriculture is predominantly citrus. There are a few acres of field crops and nurseries. Mariposa Creek is located between Duck Slough and Deadman (Dutchman's) Creek and moves water into Duck Slough in the eastern portion of the coalition's agricultural land (Table 9, Figure 13).

Deane Drain @ Gurr Road (4,702 irrigated acres) – Located west of the city of Merced, the watershed is a small watershed that has a large amount of rice and field crops. Other crops make up a very small portion of the agriculture in the watershed. The watershed drains the land west of Merced and could receive both urban stormwater and treated waste water. The drain eventually empties into Owen's Creek (Table 10, Figure 13).

Cavill Drain @ McGee Road (13,751 irrigated acres) – Located in the foothills in the northeastern portion of the Coalition region, the drain may receive urban stormwater and treated wastewater from Oakdale. Although this is a relatively large land area, the watershed is designated as small because it consists almost entirely of irrigated and nonirrigated pasture and less than a thousand acres of traditional agricultural crops (Table 10, Figure 11).

Owens Creek @ Kibby Road (4,828 irrigated acres) – Owens Creek flows out of the Sierra foothills and crosses through the southern portion of the town of Planada. The monitoring location is located downstream of Planada and may receive both stormwater effluent and water from treatment plants. The primary agriculture in the watershed is orchards and row crops, with some irrigated pasture upstream (Table 9, Figure 13).

Cottonwood Creek @ Six mile road (443 irrigated acres) – This is the smallest of the watersheds selected for monitoring. Its headwaters are in the Sierra foothills and it has a confluence with Black Rascal Creek. Citrus orchards is the primary crop (Table 10, Figure 13)

Hatch Drain @ Monte Vista Ave (1,411 irrigated acres) – This small watershed is located in the western portion of the Coalition region in Stanislaus County. The two major crops are citrus and field crops (Table 11, Figure 11).

Berenda Creek @ Road 19 (16,789 irrigated acres) – This is an intermediate sized watershed that flows west through Madera County. It is located immediately north and is adjoining to the Dry Creek watershed. Berenda Creek flows into western Madera County and does not generally have a confluence with the San Joaquin River or the Eastside Bypass. Flows infiltrate and only in major storm events do the flows reach the western portion of the county. The majority of the agriculture in the watershed is nut orchards and vineyards (Table 11, Figure 14).

Deadman Creek @ Highway 59 (22, 354 irrigated acres) – This is an intermediate sized watershed that is predominantly orchards and field crops. Grains and hays, and nurseries make up the majority of the remaining acreage. This watershed is part of the Deadman/Dutchman Creek watershed (Table 10, Figure 13).

Livingston Drain @ Robin Ave (2,418 irrigated acres) – Livingston Drain is located in the west central portion of the Coalition region in Merced County. It is located west of Atwater and Livingston. The agriculture is almost entirely citrus (Table 11, Figure 12).

Western States Drain @ Central Ave (6,109 irrigated acres) – This drain is located in the western portion of the coalition region adjacent to Hilmar Drain. The agriculture is primarily field crops with a smaller amount of citrus (Table 11, Figure 12).

Westport Drain @ Vivian Road (755 irrigated acres) – This watershed is located adjacent to the Hatch Drain watershed in the western portion of the Coalition region. The primary agriculture in this watershed is citrus and field crops (Table 11, Figure 11).

Table 6. Acreages of various land use types in the watersheds selected for monitoring. The land uses are designated as irrigated/non-irrigated, and within each watershed, the total length of the hydrologic features in meters is provided as the row labeled hydrology. See text for descriptions of the watersheds.

Land Use	I/NI	Duck Slough @ Gurr Rd.	Duck Slough @ Pioneer Rd.	Highline Canal @ Lombardy	Highline Canal @ Hwy 99
Citrus	I	3,841.0	3,592.8	4,537.6	8,178.2
Deciduous nut and fruit	I				
Field crop	I	5,188.1	1,426.9	1,502.7	2,218.9
Field crop	N				
Grain and hay	I	1,034.7	229.9	605.7	605.7
Grain and hay	N	182.8	177.4	701.3	721.6
Idle	I	653.2	145.9	38.0	122.6
Wild vegetation	N	43,488.3	39,254.2	207.0	236.0
Water surface	N	119.1	53.9		5.0
Pasture	I	4,694.5	1,104.2	1,084.7	1,360.1
Pasture	N	47.5	37.7	306.3	437.5
Rice	I	474.7			
Feedlot, dairy, farmstead	N	591.6	120.5	293.1	413.7
Truck, nursery, berry	I	1,229.5	395.1		212.4
Urban	N	530.4	172.2	130.5	937.8
Golf course, cemetery, landscape	N	2.7		22.4	81.4
Vineyard	I			1,427.3	1,886.7
Total acres		**62,078.3**	**46,710.7**	**10,856.5**	**17,417.6**
Hydrology (m)		74,920.7	31,234.6	40,762.5	48,407.5

Table 7. Acreages of various land use types in the watersheds selected for monitoring during the 2005 dormant and 2005 irrigation seasons. The land uses are designated as irrigated/non-irrigated, and within each watershed, the total length of the hydrologic features in meters is provided as the row labeled hydrology. See text for descriptions of the watersheds.

Land Use	I/N	Ash Slough @ Ave. 21	Bear Creek @ Kibby Rd.	Cottonwood Creek @ Rd. 20	Dry Creek @ Rd. 18	Dry Creek @ Wellsford Rd
Citrus	I		46.6	1,330.6	234.9	37.1
Deciduous nut and fruit	I	4,535.7	3,403.4	11,139.4	7,594.0	3,048.0
Field crop	I	4,233.9	738.3	5,391.1	899.6	2,498.0
Field crop	N					
Grain and hay	I	1,777.9	144.7	994.1	1,196.8	
Grain and hay	N	586.9		1,144.6		48.6
Idle	I	1,841.3	72.1	1,253.8	719.0	113.6
Wild vegetation	N	23,460.3	164.8	40,942.3	718.8	20,761.4
Water surface	N			419.3	11.9	47.8
Pasture	I	2,906.6	923.0	707.5	414.1	5,692.8
Pasture	N					
Rice	I					248.5
Feedlot, dairy, farmstead	N	204.2	87.9	651.9	357.9	590.0
Truck, nursery, berry	I	193.4	951.3	244.0	17.4	
Urban	N	3,829.6		7,904.9	1,968.3	157.5
Golf course, cemetery, landscape	N	18.2		146.5	28.9	
Vineyard	I	5,526.1		92,363.1	4,372.1	472.3
Total acres		**49,114.1**	**6,531.9**	**164,633.1**	**18,533.5**	**33,715.5**
Hydrology (m)		77,091.7	26,096.0	290,362.4	72,673.9	116,807.2

Table 8. Acreages of various land use types in the watersheds selected for monitoring during the 2005 dormant and 2005 irrigation seasons. The land uses are designated as irrigated/non-irrigated, and within each watershed, the total length of the hydrologic features in meters is provided as the row labeled hydrology. See text for descriptions of the watersheds.

Land Use	I/N	Hilmar Drain @ Central Ave.	Jones Drain @ Oakdale Rd.	Merced River @ Santa Fe	Prairie Flower Drain @ Crows Landing Rd.
Citrus	I	31.7		45.4	3.8
Deciduous nut and fruit	I		1,209.1	11,903.5	
Field crop	I	1,038.0	289.6	4,749.0	1,558.8
Field crop	N			140.1	
Grain and hay	I			653.7	
Grain and hay	N			86.4	
Idle	I		370.9	141.1	
Wild vegetation	N		88.8	69,891.3	41.2
Water surface	N	13.9		214.2	22.0
Pasture	I	588.0	252.6	3,332.7	1,009.7
Pasture	N			97.1	
Rice	I				
Feedlot, dairy, farmstead	N	178.9	46.9	703.6	337.5
Truck, nursery, berry	I			400.8	37.6
Urban	N		102.0	78.8	26.9
Golf course, cemetery, landscape	N			176.6	
Vineyard	I		17.6	2,176.4	
Total acres		**1,850.5**	**2,377.4**	**94,790.8**	**3,037.4**
Hydrology (m)		5,205.0	6,493.4	162,288.4	9,985.0

Table 9. Acreages of various land use types in the watersheds selected for monitoring during the 2005 dormant and 2005 irrigation seasons. The land uses are designated as irrigated/non-irrigated, and within each watershed, the total length of the hydrologic features in meters is provided as the row labeled hydrology. See text for descriptions of the watersheds.

	I/N	Owens Creek @ Kibby Rd	Mariposa Cr @ Simonson Way	Mattos Drain @ Range RD	Silva Drain @ Meadow Dr	Black Rascal Cr @ Kibby Rd	Root Creek
Citrus	I	4.4	328.6		340.7	514.3	2,536.2
Deciduous nut and fruit	I	1,136.4					4,094.2
Field crop	I	842.1	89.9	107.9	99.7	642.2	359.9
Grain and hay	I	527.1				11.4	872.3
Grain and hay	N						
Idle	I	57.8	31.3				53.8
Wild vegetation	N	411.1	16.6	672.2	55.5		256.9
Water surface	N						35.0
Pasture	I	1,457.1		1,022.2	11.7	82.7	158.4
Pasture	N						
Rice	I						
Feedlot, dairy, farmstead	N	201.3	12.8		129.5	12.7	21.1
Truck, nursery, berry	I	803.3	46.3		24.2	155.6	20.3
Urban	N	87.1					3.2
Golf course, cemetery, landscape	N						
Vineyard	I						282.8
Area outside study area	N						
Total acres		5,527.9	525.5	1,802.4	661.3	1,418.9	8,693.9
Irrigated acres		4,828.4	496.1	1,130.2	476.3	1,406.2	8,377.8

Table 10. Acreages of various land use types in the watersheds selected for monitoring during the 2005 dormant and 2005 irrigation seasons. The land uses are designated as irrigated/non-irrigated, and within each watershed, the total length of the hydrologic features in meters is provided as the row labeled hydrology. See text for descriptions of the watersheds.

	I/N	CavilllDr @ McGee Rd	Cottonwood Cr @ Six Mile Rd	Deadman Cr @ Hwy 59	Deanne Dr @ Gurr Rd	Mustang Creek @ East Ave.
Citrus	I	116.1	122.6	38.9		4,000.1
Deciduous nut and fruit	I			5,582.4		
Field crop	I	591.9		6,626.4	1,044.4	1,790.3
Grain and hay	I	15.1		2,018.8	39.8	1,045.2
Grain and hay	N			78.1		
Idle	I		7.0	2,057.6	659.7	
Wild vegetation	N	73.4	198.9	15,471.4	101.4	193.4
Water surface	N	26.0		192.8		5.0
Pasture	I	13,028.0	227.0	3,187.1	585.4	320.0
Pasture	N					
Rice	I			67.2	2,331.5	
Feedlot, dairy, farmstead	N	208.4	2.0	588.0	60.8	31.1
Truck, nursery, berry	I		81.0	1,844.7	40.7	
Urban	N	72.1	114.9	139.1	22.8	
Golf course, cemetery, landscape	N		21.6			
Vineyard	I		5.2	930.7		5,244.2
Area outside study area	N					
Total acres		14,131.0	780.2	38,823.3	4,886.6	12,629.2
Irrigated acres		13,751.1	442.8	22,353.9	4,701.6	12,399.7

Table 11. Acreages of various land use types in the watersheds selected for monitoring during the 2005 dormant and 2005 irrigation seasons. The land uses are designated as irrigated/non-irrigated, and within each watershed, the total length of the hydrologic features in meters is provided as the row labeled hydrology. See text for descriptions of the watersheds.

	I/N	Dutchman Cr @ Hwy 99	Beranda Sl @ Dairyland Rd	Beranda C r@ Rd 19	Hatch Drain @ Monte Vista	Livingston Dr @ Robin Ave	Western Sts Dr @ Central Ave	Westport Dr @ Vivian Rd
Citrus	I	38.9	57.6	650.7	400.3	1,789.4	982.9	292.4
Deciduous nut and fruit	I	5,078.1	9,010.0	7,554.4				
Field crop	I	1,145.5	2,738.0	1,229.6	565.3		4,109.2	356.4
Grain and hay	I	594.0	666.9	93.7		60.5	4.8	
Grain and hay	N	78.1	185.3	2,176.2				
Idle	I	422.8	3,258.7	125.4	13.3	49.6		21.7
Wild vegetation	N	347.7	20,687.2	16,837.7		215.5	102.8	
Water surface	N	36.4	185.9	143.3	3.9		118.5	
Pasture	I	445.0	917.2	392.2	425.8	215.2	948.3	
Pasture	N							
Rice	I	100.2						
Feedlot, dairy, farmstead	N	100.2	485.0	499.0	88.8	129.1	653.6	78.8
Truck, nursery, berry	I	587.6	7.6	82.0	6.2	282.3	63.4	
Urban	N	14.3	742.5	894.9	52.9	110.9	54.7	
Golf course, cemetery, landscape	N		10.9				90.2	
Vineyard	I	324.6	3,178.0	6,661.2		21.1		84.1
Area outside study area	N							
Total acres		9,313.4	42,130.7	37,340.4	1,556.5	2,873.5	7,128.5	833.4
Irrigated acres		8,736.7	19,833.9	16,789.3	1,411.0	2,418.0	6,108.7	754.7

Location Maps of Sample Sites and Watershed Land Use

Maps of all the sample sites and the land use upstream of the sites are provided below in Figures 10-14. The legend for all land uses is provided in Figure 10a. See text above for details of the sampling sites and land use.

Figure 10. Coalition map showing all subwatersheds identified for sampling.

ESJWQC - Watershed land use

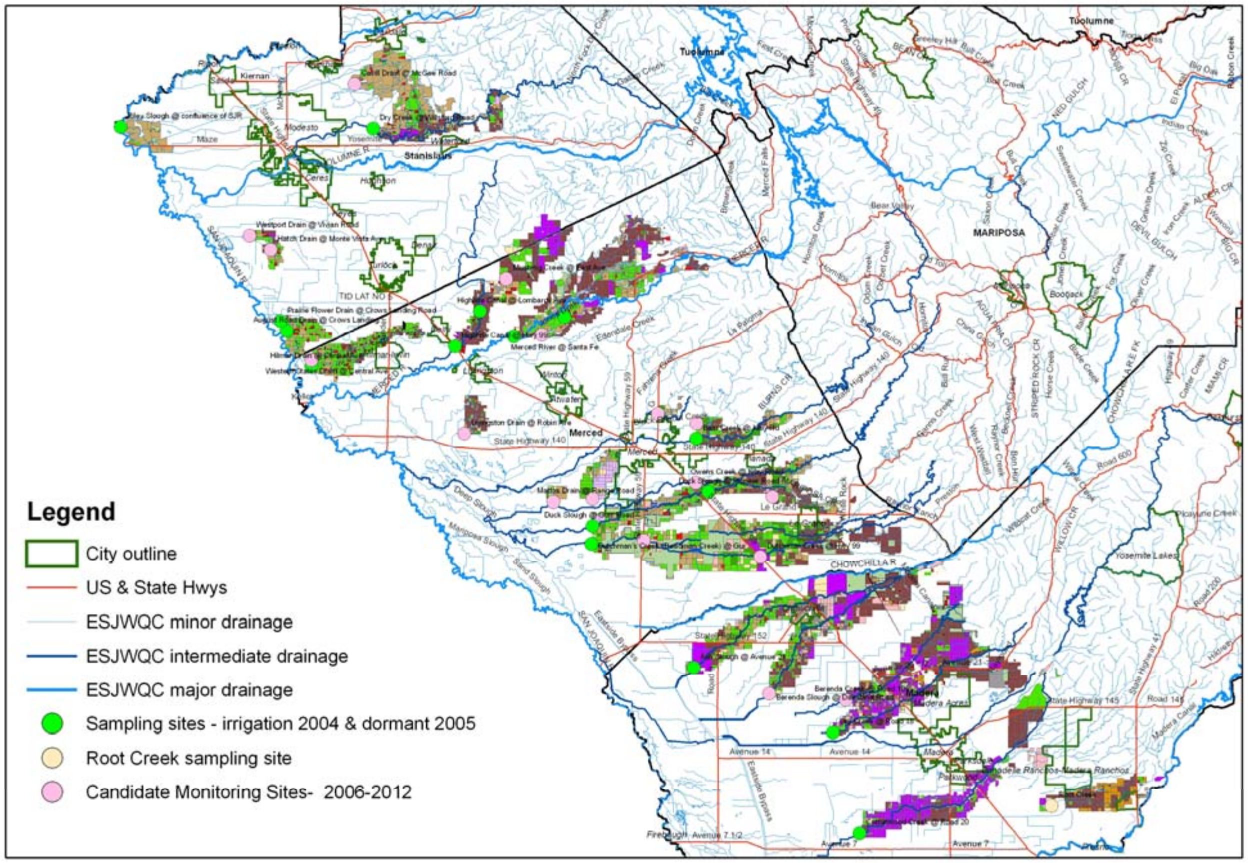


Figure 10a. Legend for land use.

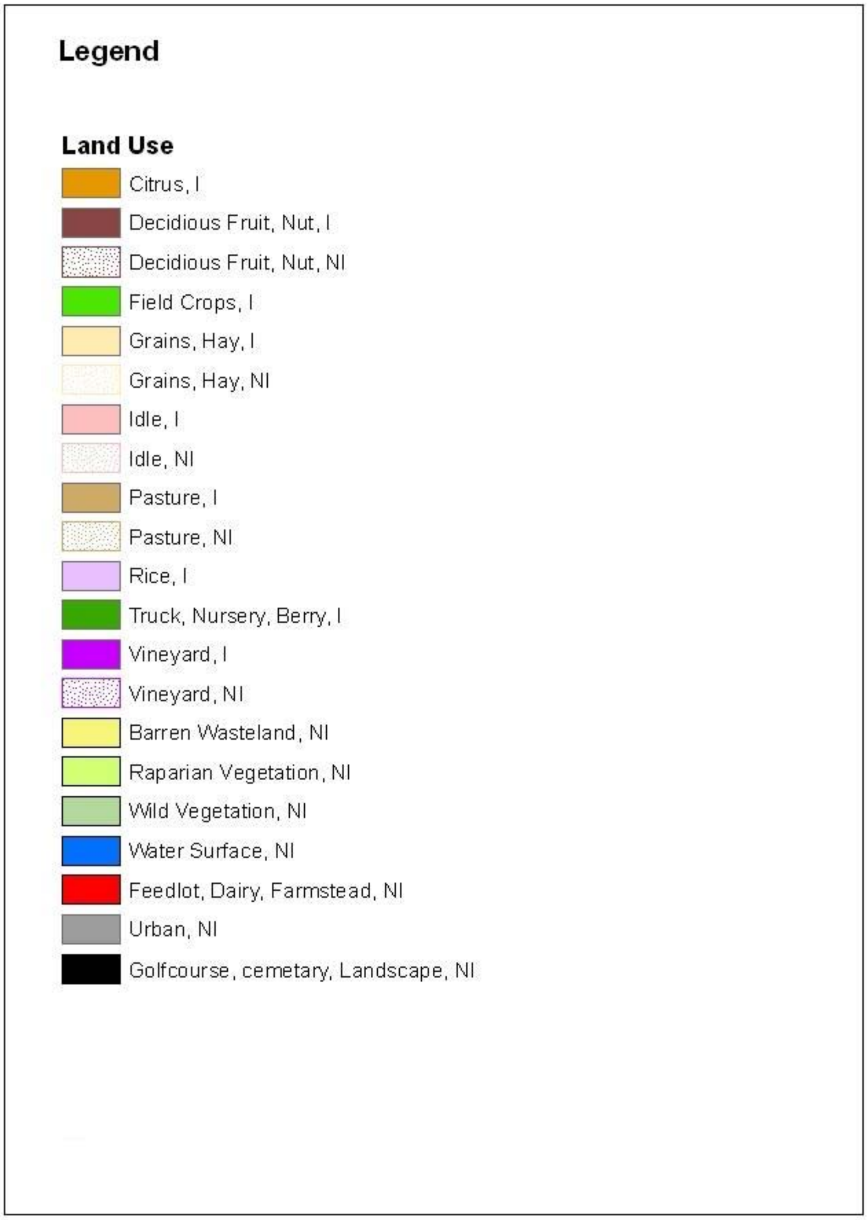


Figure 11. Land use for subwatersheds in Stanislaus County: Cavill Drain @ McGee Rd., Hatch Drain @ Monte Vista Ave., and Westport Drain @ Vivian Rd. Riley Slough was abandoned after the 2004 irrigation season due to access problems.

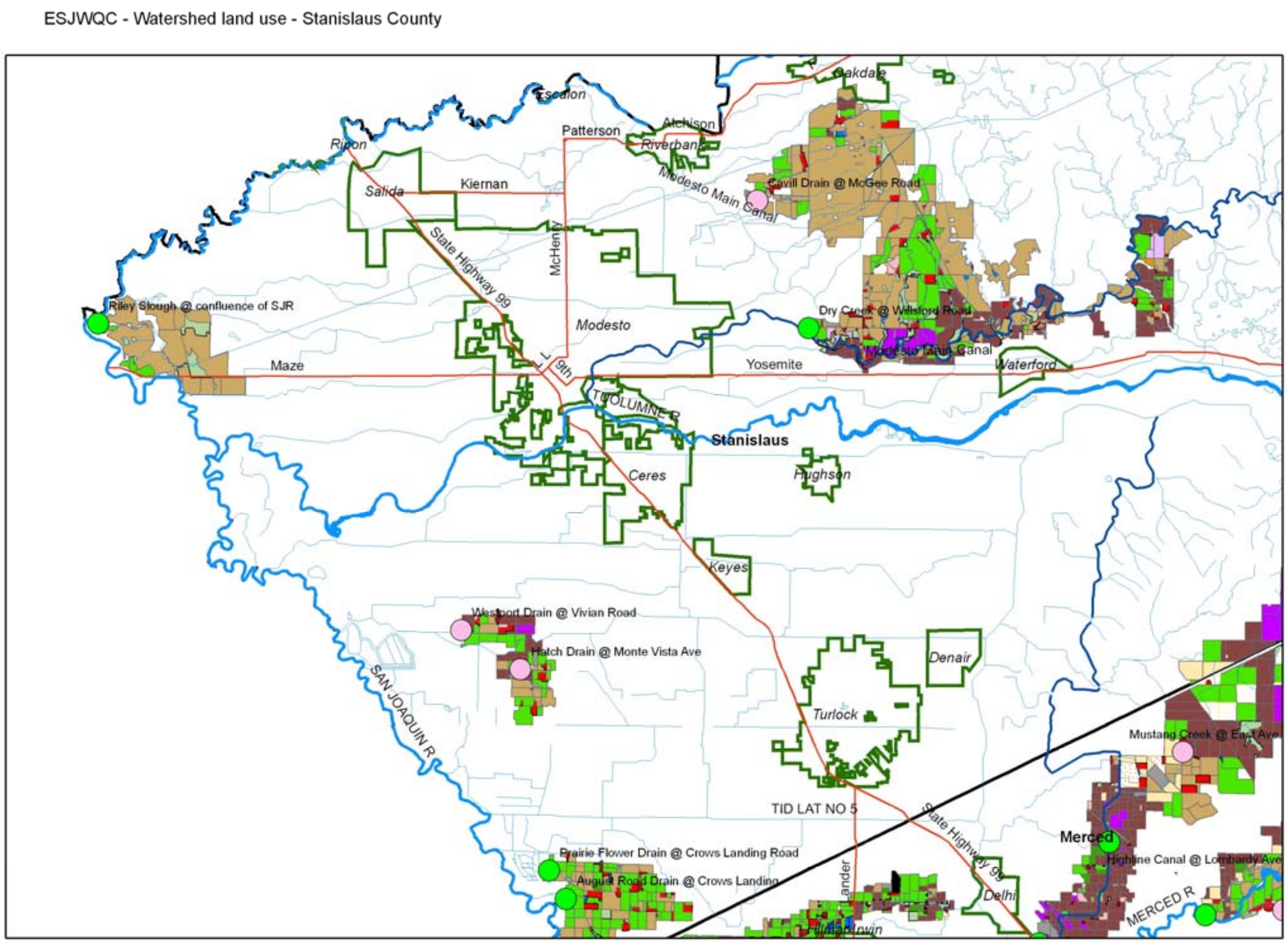


Figure 12. Land use for subwatersheds in northern Merced County: Mustang Creek @ East Ave., Livingston Drain @ Robin Ave., Western States Drain @ Central Ave., and Silva Drain @ Meadow Drive.

ESJWQC - Watershed land use - Merced County north

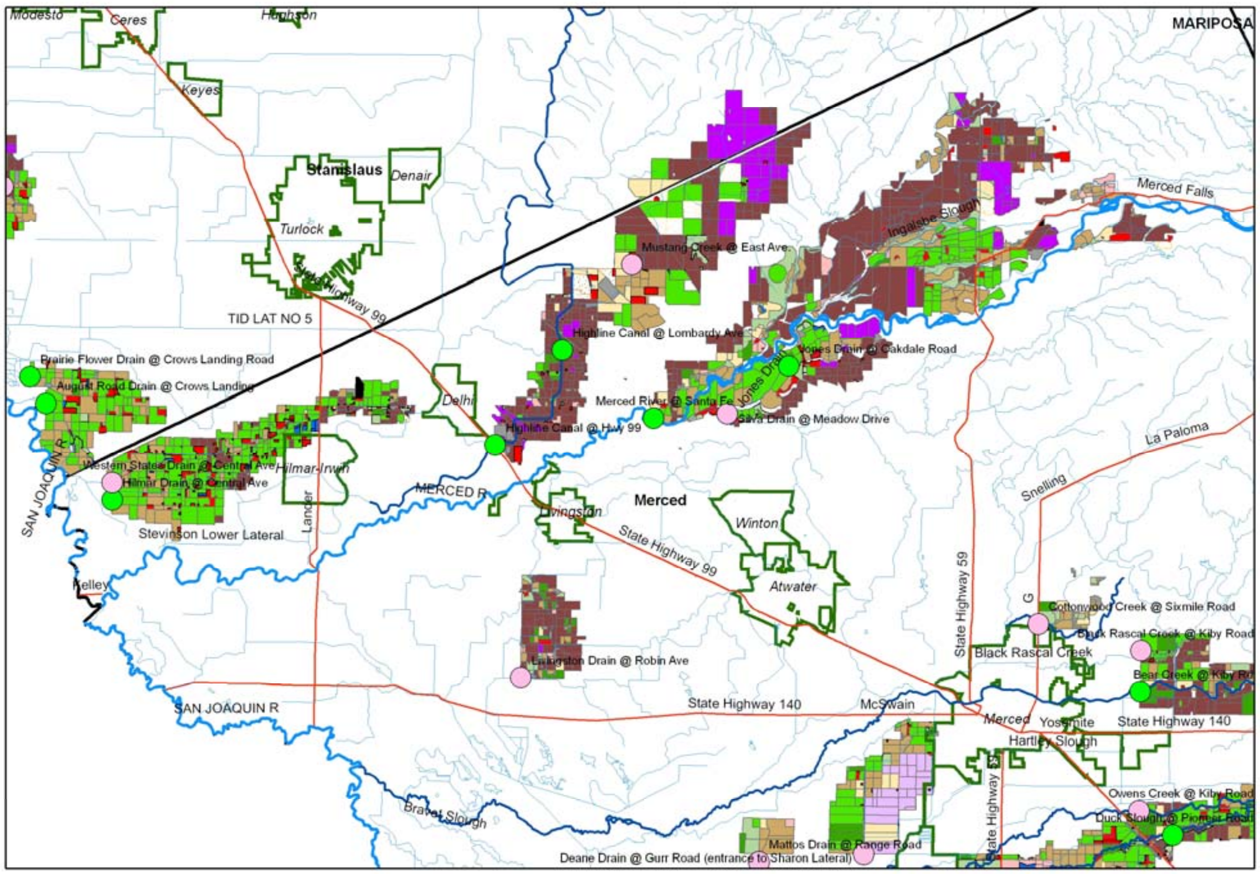


Figure 13. Land use for subwatersheds in southern Merced: Owens Creek @ Kibby Rd., Mariposa Creek @ Simonson Way, Mattos Drain @ Range Rd., Black Rascal Creek @ Kibby Rd., Dutchman Creek @ Hwy 99, Cottonwood Creek @ Six Mile Rd., Deadman Creek @ Hwy 59, and Deanne Drain @ Gurr Rd.

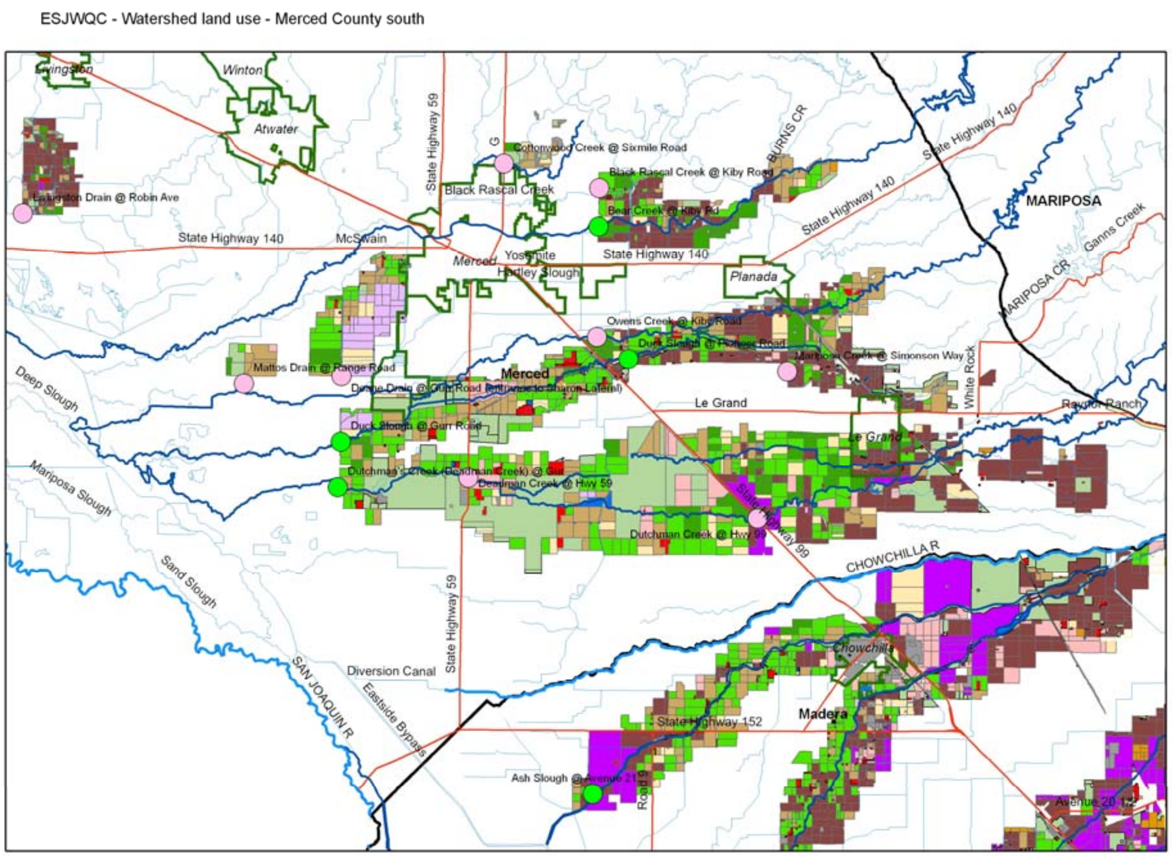


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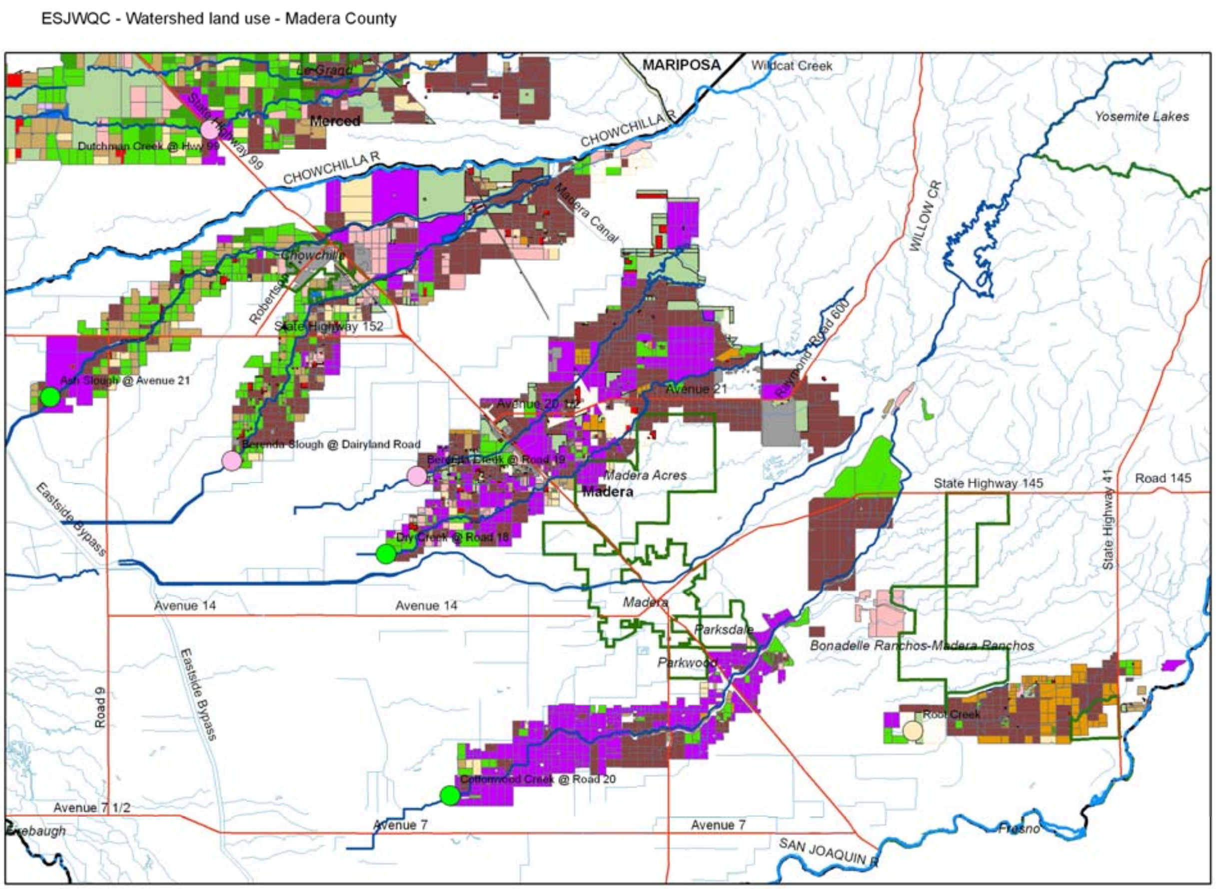
Figure 14. Land use for subwatersheds in Madera County: Berenda Slough @ Dairyland Rd., Berenda Creek @ Kibby Rd., and Root Creek.



Crops, Agriculture Production Practices and Chemicals Applied

There are a wide range of crops grown in the Coalition region. The major crops are wine grapes and nut orchards, primarily almonds. Some stone fruits such as peaches are grown throughout the Coalition region. Toward the southern end of the coalition region, cotton can be grown and citrus is common. Field crops are grown throughout the region including a variety of vegetables and melons. These crops tend to be grown closer to the San Joaquin River and somewhat toward the northern portion of the region.

Production practices vary based on crop type, soils, climate and other factors. Individual crop production calendars (Tables 12-17) illustrate when specific management practices are performed throughout a year for six major crops in the Coalition area: irrigated pasture, prunes, walnuts (and other nut crops), alfalfa, peaches, and processing tomatoes. These calendars were originally developed based on timing in the Sacramento Valley, but recent conversations with coalition members indicate that the timing in the San Joaquin Valley is comparable. The calendars are meant to represent the average timing of activities. The actual timing of production activities varies from year to year based on climatic and pest conditions. Mild winters may accelerate some activities, while late outbreaks of pests may delay the application of chemicals. On average however, these activities are undertaken in the months indicated.

A review of historical water quality monitoring data by CVRWQCB staff has shown that production practices impact surface water primarily through storm water runoff and irrigation return flows. Winter storm water runoff may transport pesticides applied to dormant orchards to off site water bodies. Sediment from orchards or tilled fields (row/field crops) may also be transported off site during winter runoff events, often carrying pesticides with affinity for sediment (high K_{oc} values). Winter runoff also may contain nutrients and *E. coli* from pasture and confined animal facilities[1]. During the summer, irrigation return flows can transport pesticides applied prior to irrigation, sediment (with associated pesticides/nutrients) from tilled fields (row/field crops), dissolved salts, *E. coli* from irrigated pasture, and nutrients from either irrigated pasture or fertilized (manure/chemical fertilizers) crops.

[1] Confined Animal Facilities (CAFOs) are not addressed in the Ag Waiver, but are covered by other CVRWQCB regulatory programs. However, impacts from CAFOs can be detected in Coalition watershed monitoring efforts.

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Table 12. Alfalfa Production - Calendar of Operations in the San Joaquin Valley

(Source: University of California Cooperative Extension. Dan Putnam, Statewide Extension Specialist, Rachael Long, Jerry Schmierer, Mick Canevari, and Allan Fulton, UC Farm Advisors)

Crops are complex biological systems, which makes it difficult to accurately predict every management practice. Each "X" represents a reasonable probability that the cultural practice would occur at the time indicated. Not all of these management practices are implemented in every field every year. Site-specific conditions will determine if a specific management practice is necessary.

Farm Operation	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
First Year (fall, winter, and spring plantings may occur - fall recommended)												
Soil Test	X	X	X	X	X	X	X	X	X	X	X	X
Primary Tillage (rip/level)		X	X	X				X	X			
Pre-plant Fertilizer		X	X						X	X		
Secondary Tillage (disc, harrow, pack)									X	X		
Planting disease & insect resistant varieties	X	X	X							X	X	X
Irrigation (often sprinklers for germination)			X	X					X	X		
Irrigation (flood after stand establishment)				X	X	X	X	X	X	X		
Post-emergence weed control		X	X	X						X	X	
Rodent control			X	X				X	X	X		
Egyptian alfalfa weevil control (seldom)			X									
Blue alfalfa and pea aphid control (seldom)				X	X							
Beet and yellow striped armyworm control							X	X				
Alfalfa caterpillar control							X	X				
Harvest / Curing/Baling				X	X	X	X	X	X	X		
Subsequent years (typical life of stand: 4 yrs, 6-7 cuts/year)												
Pre and post-emergence weed control	X	X	X	X	X	X	X				X	X
Plant tissue tests				X	X	X	X	X				
Fertilizer applications					X	X					X	X
Rodent control	X	X	X	X				X	X	X	X	X
Irrigation				X	X	X	X	X	X	X		
Egyptian alfalfa weevil control			X	X								
Blue alfalfa and pea aphid control (seldom)				X	X							
Beet and yellow striped armyworm control							X	X				
Alfalfa caterpillar control							X	X	X			
Harvest/Curing/Baling				X	X	X	X	X	X	X		

Table 13. Almond Production - Calendar of Operations in the San Joaquin Valley
(Source: University of California Cooperative Extension. Joe Connell, Bill Krueger, Richard Buchner, Wilbur Reil, Franz Niederholzer, and Allan Fulton, UC Farm Advisors)

Crops are complex biological systems, which makes it difficult to accurately predict every management practice. Each "X" represents a reasonable probability that the cultural practice would occur at the time indicated. Not all of these management practices are implemented in every field every year. Site-specific conditions will determine if a specific management practice is necessary.

Farm Operation	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Pruning and brush disposal	X	X	X				X				X	X
Dormant season insect management	X											
Winter sanitation for insect control	X											
Pre-emergence weed control (in-row)	X	X									X	X
Pollination (honey bees)		X	X									
Frost Protection		X	X	X								
Vegetation management (middles)			X	X	X	X	X	X	X			
Shot hole disease management			X	X								
Brown rot disease management		X										
Scab disease management				X	X							
Anthracnose disease management		X	X	X	X							
Rust management						X	X	X				
Irrigation				X	X	X	X	X	X	X		
Leaf analysis for nutrient management							X					
Fertilizer and gypsum application			X	X		X	X					
Vertebrate pest management	X	X	X	X	X	X	X			X	X	X
Foliar fertilization			X	X	X						X	
In-season insect management (w/o dormant):												
Navel Orange Worm					X	X	X					
Peach twig borer		X			X		X					
San Jose Scale				X								
Ants						X	X					
Web spinning mites						X	X	X				
Post-emergence herbicides (in-row)				X	X	X	X	X				
Harvest								X	X	X		

Table 14. Irrigated Pasture - Calendar of Operations in the San Joaquin Valley

(Source: University of California Cooperative Extension. Larry Forero, Glenn Nader, Barbara Reed, and Allan Fulton, UC Farm Advisors)

Crops are complex biological systems, which makes it difficult to accurately predict every management practice. Each "X" represents a reasonable probability that the cultural practice would occur at the time indicated. Not all of these management practices are implemented in every field every year. Site-specific conditions will determine if a specific management practice is necessary.

Farm Operation	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
First Year												
Pre-plant soil test									X			
Pre-plant fertilizer									X			
Seedbed preparation (disc, harrow, pack)									X			
Planting (fall planting recommended)										X		
Post-emergence irrigation (if rain absent)										X		
Spring planting (alternatively)			X	X								
Broadleaf weed management				X								
Pull checks and irrigate				X	X	X	X	X	X	X		
Haying or grazing					X	X	X	X	X	X		
Subsequent years (typical life: 5 – 7 years)												
Leaf tissue analysis				X	X							
Fertilizers applied			X	X	X							
Weed and blackberry management				X	X			X	X	X		
Irrigation				X	X	X	X	X	X	X		
Clip (if feed is not grazed sufficiently)						X	X	X				
Harrow (aerate, remove thatch, etc…)			X									
Haying or grazing				X	X	X	X	X	X	X		

Table 15. Peach Production - Calendar of Operations in the San Joaquin Valley

(Source: University of California Cooperative Extension. Janine Hasey, Bill Olson, Richard Buchner and Allan Fulton, UC Farm Advisors)

Crops are complex biological systems, which makes it difficult to accurately predict every management practice. Each "X" represents a reasonable probability that the cultural practice would occur at the time indicated. Not all of these management practices are implemented in every field every year. Site-specific conditions will determine if a specific management practice is necessary.

Farm Operation	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Prune and brush disposal	X	X									X	X
Shot hole disease management	X										X	X
Leaf Curl disease management	X	X										X
Dormant season insect management	X	X										X
Vegetation management (middles)			X	X	X	X	X	X	X	X		
Post-emergence herbicides (in-row)				X	X	X	X					
Brown rot disease management		X	X				X					
Powdery mildew management			X	X	X							
Rust management				X	X							
Hand fruit thinning				X	X	X						
Irrigation				X	X	X	X	X				
Fertilizer application				X				X				
In-season insect management (w/o dormant)												
Oriental fruit moth					X	X	X					
Peach twig borer					X	X						
Leafrollers (OBLR)				X	X	X						
Hemiptera bugs				X	X							
Thrips			X									
Web spinning mites						X	X	X				
Hand harvest							X	X	X			
Pre-emergence herbicides (in-row)											X	X

Table 16. Processing Tomato Production – Calendar of Operations in the San Joaquin Valley

(Source: University of California Cooperative Extension. Gene Miyao, Michael Murray, and Allan Fulton, UC Farm Advisors)

Crops are complex biological systems, which makes it difficult to accurately predict every management practice. Each "X" represents a reasonable probability that the cultural practice would occur at the time indicated. Not all of these management practices are implemented in every field every year. Site-specific conditions will determine if a specific management practice is necessary.

Farm Operation	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Primary tillage (disk, subsoil, landplane)							X	X	X	X		
Spring tillage (limited)			X	X	X							
Soil amendments (gypsum etc…)								X	X	X		
Soil test									X	X		
List beds and shape								X	X	X		
List beds and shape (spring) limited			X	X	X							
Late winter/spring weed control	X	X	X	X								
Pre-plant & post emergence herbicides		X	X	X	X	X						
Direct seed planting		X	X	X	X							
(or) transplant			X	X	X	X						
Starter fertilizers		X	X	X	X	X						
Tissue tests, post-plant side-dress fertilizer			X	X	X	X						
Layby herbicides			X	X	X	X						
Irrigation (end early Sept)			X	X	X	X	X	X				
Cultivation			X	X	X	X	X	X				
Water-run N fertilizer						X	X	X				
Bacterial speck control			X	X								
Russet mite and flea beetle control			X	X	X							
Black mold control								X	X	X		
Cutworm control				X	X	X						
Potato aphid control						X	X	X				
Beet Armyworm control						X	X	X	X			
Tomato fruit worm control							X	X	X			
Stink bug control						X	X	X	X			
Ethephon Harvest Aid						X	X	X	X			
Harvest							X	X	X	X		

Table 17. Prune Production - Calendar of Operations in the San Joaquin Valley
(Source: University of California Cooperative Extension. Richard Buchner, Bill Olson, Franz Niederholzer, Wilbur Reil, Bill Krueger, and Allan Fulton, UC Farm Advisors)

Crops are complex biological systems, which makes it difficult to accurately predict every management practice. Each "X" represents a reasonable probability that the cultural practice would occur at the time indicated. Not all of these management practices are implemented in every field every year. Site-specific conditions will determine if a specific management practice is necessary

Farm Operation	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Pruning And Brush Disposal	X	X	X	X							X	X
Dormant Season Insect Management	X	X									X	X
Brown Rot Disease Management			X									
Scab Disease Management			X									
Vertebrate Pest Management				X	X	X						
Prune Rust Disease Management					X	X	X					
Insect Management (W/O Dormant):												
Mealy Plum Aphid			X	X	X	X	X					
Leaf Curl Plum Aphid			X	X								
Peach Twig Borer			X	X	X							
Oblique Banded Leafroller			X		X	X						
Scale (Crawlers)					X							
Web Spinning Mites						X	X					
Mechanical Thinning				X	X							
Vegetation Management (Middles)				X	X	X	X	X	X	X		
Irrigation				X	X	X	X	X	X			
Nitrogen Fertilizer				X	X	X	X					
Potassium/Gypsum Fertigation					X	X	X					
Foliar Potassium Fertilizer Application					X	X	X					
Leaf Tissue Analysis							X					
Harvest								X	X			
Replace Trees – Backhoe And Fumigate									X	X	X	
Leaf Removal And Foliar Zinc Application										X	X	
Soil Applied Potassium Fertilizer										X	X	X

Agriculture Chemicals

Use

Chemicals used on irrigated farmland vary by crop, pest, seasonal restrictions, Integrated Pest Management (IPM) considerations and other factors. Based on data obtained from the California Department of Pesticide Regulation (CDPR) online database, 12 million lbs. of agricultural chemicals (insecticides, herbicides and fungicides, etc.) were used in crop production in the coalition region in 2002. This figure contains pesticides that the CVRWQCB has linked to water quality concerns, but also includes products such as mineral oil, which are not thought to contribute to water quality impacts.

The potential threat to surface water quality posed by each of these pesticides can vary widely and is based on physical and toxicological characteristics of the pesticide, application method, time of year applied, and weather conditions during application, among other factors.

The registrants of diazinon, an insecticide listed as impairing water quality in several waterways in the Coalition region, have recently enacted new California label changes that require use of BMPs when applying the product to orchards during the dormant season. The registrants for Lorsban (chlorpyrifos), are in the process of revising the US EPA product label to include practices for protecting water quality that are expected to be in place by 2005.

The Coalition has been requesting Pesticide Use Reports (PURs) directly from the County Agricultural Commissioner's offices since the summer of 2004. We request PURs for counties for two week periods immediately preceding sampling if any chemicals were detected in the water collected from any of the monitoring locations. We included all pesticide use information that is currently available to the CVRWQCB as part of the semi-annual monitoring report submitted January 3, 2006. Consequently, we will not submit the information as part of this Watershed Evaluation Report.

Application Methods

The majority of pesticides in the coalition area are applied using either ground or aerial equipment. (See Crop Production Calendars in Tables 12-17 for timing of applications). A small percentage of acreage is treated with backpack sprayers. Although application methods are generally the same from year to year, there are variations due to soil moisture conditions, type of chemical applied, encroaching development, and availability of applicators. Consequently, it is not possible to definitively assign an application method to any field in the coalition region and be confident that the method will be used across numerous years. Some of the counties report application method as part of the pesticide use information that the Coalition receives. However, not all counties provide the information and obtaining application methods would be cost prohibitive.

- Orchards: Ground operated air blast sprayers are the most common method of chemical application. Aerial equipment is also used to spray for pests in the tree canopy. Herbicides are applied to orchard floors using ground equipment. Fertilizers are applied by ground and may be applied topically or injected into the soil.

- Row/Field crops: Ground operated nozzle/mist sprayers and aerial equipment are commonly used to spray for pests in the crop canopy, or in the case of herbicides directly to the weeds and/or soil. Fertilizers are applied by ground (topically or injected) and by air.

Management Practices

40 CFR 130.2(m) defines Best Management Practices (BMPs) as "methods, measures, or practices selected by an agency to meet its nonpoint source control needs. BMPs include but are not limited to structural and nonstructural controls and operation and maintenance procedures. BMPs can be applied before, during, and after pollution-producing activities to reduce or eliminate the introduction of pollutants into receiving waters." 40 CFR 130.6(c)(4)(i) (nonpoint source management and control) states, "economic, institutional, and technical factors shall be considered in a continuing process of identifying control needs and evaluating and modifying the BMPs as necessary to achieve water quality goals."

The Coalition and cooperating entities have compiled lists of Best Management Practices programs applicable to crops grown in the coalition area and that are either currently in use or have shown promise in working with growers to protect surface water. Table 18 provides a summary of BMP related programs within the Coalition area. Depending on the constituent and existing field and crop management practices, a landowner or operator might need to implement anywhere from a single BMP to numerous BMPs to reduce or eliminate a threat to water quality. Through the coalition cooperating entities, landowners or operators will have access to experts from various public and private firms who can provide assistance in selecting and installing BMPs. The BMP Compilation for each crop contains a description of chemicals used on major crops grown in the coalition region along with BMPs that have the potential to prevent surface water contamination due to off site movement of chemicals and sediment. The BMP compilations completed to date are provided in Appendix 2.

Information on the effectiveness of BMPs in reducing pollution varies depending on the individual practice. Many of the BMPs in use or with potential for widespread use are currently being researched to determine effectiveness in California. Limited information on BMPs is available from other parts of the country that may or may not be relevant to California growing conditions. Numerous programs are examining the effectiveness of BMPs or can provide assistance to landowners in selection and installation of BMPs. Over the next two years, research projects performed by various entities are expected to develop considerable new data on these practices.

Table 18. Summary of BMP related programs within the Coalition area.

Agency	Program Description	Publications	Outreach
Natural Resources Conservation Service	Information on BMPs related to land management, sediment transport and habitat protection, among other areas.	The NRCS "Index of Conservation Practices and Specifications" list hundreds of practices and information on installation.	NRCS organizes field days and workshops to promote adoption of management practices. Funding: Landowners are eligible for grants and other financial assistance through the Environmental Quality Incentive Program (EQIP) and (other programs).
University of California Cooperative Extension	Information on pest management, irrigation management and pesticide safety among other areas. Also performs research on various production practices.	The U.C Agriculture and Natural Resources (UCANR) Publications department has developed "Production Manuals" for six major crops and "Integrated Pest Management (IPM) Guidelines" for 29 crops grown in the Central Valley. These publications include information on low risk pest and nutrient management practices that would often be components of an overall farm plan to protect surface water.	UC Farm Advisors organize regular grower update meetings on various crop and pest management issues. Continuing education credits are provided to growers who attend for maintaining county pesticide application permits.

Commodity Groups (Plums, Almonds, Peaches, Tomatoes, Walnuts, Melons):	Information on production practices, research funding; outreach programs to growers.	Each commodity group has various reference materials for growers outlining crop management practices.	Each commodity group holds an annual meeting along with regional meetings with presentations on production issues. Each group also has periodic in-house newsletters that cover various marketing and production issues. California Dried Plum Board: The board is coordinating several projects that are examining the effectiveness of BMPs for the reduction of runoff from dormant orchard sprays/ Almond Board of California: The board is funding research on low risk approaches to control overwintering pests and has funded research on the effectiveness of BMPs used in almonds.
County Agricultural Commissioners:	County regulatory enforcement agency for pesticide use and handling.	Each county has a manual or handbook that outlines local and state regulations regarding handling and applying of pesticides. Growers review these manuals in advance of tests	CAC hold periodic continuing education meetings for growers and Pest Control Advisors (PCAs). These meeting can cover regulations, production practices and various subjects related to

		taken to receive a Pesticide Applicator Permit, a license needed to purchase and apply pesticides.	proper use and handling of pesticides.
Coalition for Urban/ Rural Environmental Stewardship:	A non-profit education organizing focusing on promoting pesticide and nutrient BMPs; also develops and coordinates research projects on BMPs.	CURES produces booklet on BMPs for orchard, row crops and other uses of pesticides.	CURES organizes and develops presentations for grower and PCA meetings that cover water regulations and various BMPs to protect surface water.
Resource Conservations Districts:	Grower managed entities based in each county that coordinate projects and programs related to resource management.		Outreach: RCDs organize periodic educational workshops and meetings on subject related to resource conservation.
Farm Input Suppliers:	Private firms that sell farm inputs and provide information through licensed Pest Control Advisors (PCAs)	Publications: Farm input suppliers distribute product specific information including product labels, Material safety Data Sheets (MSDS) and other publications related to proper use of farm inputs such as pesticides and nutrients.	Outreach: Staff PCAs have frequent personal contact with landowners to advise of pesticide recommendations
Natural Resources Conservation Service (NRCS)- EQIP Program:	The Environmental Quality Incentives Program (EQIP) was reauthorized in the Farm Security and Rural Investment Act of 2002 (Farm Bill) to provide a voluntary conservation program for farmers and ranchers that promotes agricultural production		EQIP activities are carried out according to an environmental quality incentives program plan of operations developed in conjunction with the producer that identifies the appropriate conservation practice or practices to

	and environmental quality as compatible national goals. EQIP offers financial and technical help to assist eligible participants install or implement structural and management practices on eligible agricultural land.		address the resource concerns. The practices are subject to NRCS technical standards adapted for local conditions. The local conservation district approves the plan.

Water Quality Improvement Programs Associated with Irrigated Lands

Current programs in the Coalition area that monitor water quality are coordinated by the United States Department of Agriculture Agricultural Research Service (ARS), Surface Water Ambient Monitoring Project (SWAMP), Department of Water Resources (DWR) and the Central Valley Regional Water Quality Control Board (CVRWQCB). Under the CVRWQCB, the following projects sample within the ESJCWQC area: Irrigated Lands Project, Total Maximum Daily Load (TMDL), National Pollutant Discharge Elimination System (NPDES) Discharges and Bioassessment. In addition, the US Geological Survey conducts monitoring and various special projects in the coalition region as part of their National Water Quality Assessment Program (NAWQA).

ARS coordinates projects within California to look at irrigation practices and their affect on water quality management. They also have programs dealing specifically with salinity and crop issues. A list of projects within the San Joaquin valley can be found at http://www.ars.usda.gov/research/programs/usmap.htm?stateabbr=CA&NP_CODE=201.

SWAMP's vision is to comprehensively measure and protect beneficial uses and adequately evaluate protection and restoration efforts in California's surface waters. SWAMP relies on the various regional water quality control boards to help in monitoring and sampling of sites throughout California. Information regarding SWAMP efforts for 2001-2004 can be found at http://www.waterboards.ca.gov/centralvalley/programs/agunit/swamp/index.html.

A list of all RWQCB for Region 5 sampling programs can be found at http://www.waterboards.ca.gov/centralvalley/programs/index.html. This includes the Irrigated Lands, TMDL, NPEDS, SWAMP and Bioassessment programs.

A summary of BMP related programs within the coalition's area is provided in Table 18. One such program is EQIP, the Environmental Quality Incentive Program. EQIP was established in the 1996 Farm Bill to provide a single, voluntary conservation program for farmers and ranchers to address significant natural resource concerns. Nationally, it provides technical and financial assistance to address natural resource concerns. Administered by the Natural resources Conservation Service (NRCS), EQIP was reauthorized in the 2002 Farm Bill and awards cost share assistance to projects that provide significant environmental benefit. Funding for EQIP comes from the Commodity Credit Corporation.

EQIP may cost-share up to 75 percent of the costs of certain conservation practices. Incentive payments may be provided for up to three years to encourage producers to carry out management practices they may not otherwise use without the incentive. However, limited resource producers and beginning farmers and ranchers may be eligible for cost-share up to 90 percent. An individual or entity may not receive, directly or indirectly, cost-share or incentive payments that, in the aggregate, exceed $450,000 for all EQIP contracts entered during the term of the Farm Bill.

In addition to the formal programs listed in Table 18, the coalitions and County Agriculture Commissioners are initiating several projects and actions to evaluate BMPs and control the movement of pesticides to surface waters. The Stanislaus County Agriculture Commissioner is in the process of requiring use permits on specific chemicals applied in the county. The Coalition for Urban/Rural Environmental Stewardship (CURES) has initiated projects in cooperation with several coalitions to evaluate the ability of BMPs to reduce the movement of pesticides to surface waters. Although none of these projects are being conducted in the ESJWQC region, these projects will provide results over the next several years that will be applicable to ESJWQC agricultural practices.

Water Quality

Historical Water Quality Data

The region has a long history of water quality studies on a variety of constituents. Sampling has been conducted on chemical water quality, toxicity, and benthic macroinvertebrate communities by several agencies and academic institutions including the Central Valley Regional Water Quality Control Board (CVRWQCB), California Department of Pesticide Regulation, California Department of Water Resources, California Department of Transportation, University of California Davis, and the U.S. Geological Survey (Tables 19-20). Constituents sampled for include organophosphate pesticides, metals, drinking water constituents, nutrients, and dissolved oxygen. An overwhelming majority of programs have monitored for organophosphate pesticides. The Coalition watershed area will continue to be monitored as part of programs such as the organophosphate Total Maximum Daily Load monitoring program, and the Agricultural Waiver Phase II monitoring program, both performed by the CVRWQCB. Some of the monitoring programs and locations are associated with monitoring storm water runoff from urban areas or transportation corridors and are not relevant when addressing runoff from irrigated agriculture other than to provide baseline information.

The Department of Pesticide Regulation's (DPR) Surface Water Database was used to investigate pesticide concentrations in the Coalition region. This database was created in 1997 by DPR under agreement with the State Water Resources Control Board. This database contains the results from approximately 34,500 samples collected from 40 different sites in the Coalition region from August 1991 through September 2003. This database was supplemented with information available to the Coalition through recent OP TMDL sampling programs and by the Coalitions' own sampling program. Data from TMDL sampling for 2003 and 2004 are available for analysis. The EPA 303d list of impaired water bodies was used to establish potential causes of impairment, and these were compared to the data available from the two databases.

In an effort to prioritize monitoring locations in the ESJWQC watershed, this report examines four causes of water quality impairment: the pesticides diazinon, chlorpyrifos, and sediment binding pesticides (pyrethroids), and general toxicity. Diazinon was chosen because of its documented impairment of several streams on the 303d list, proposed basin plan amendment and TMDL monitoring program. Chlorpyrifos was included due to its inclusion as a leading cause of water column toxicity in the Regional Board's Phase 1 testing of agricultural drains in the summer of 2003. The final group of pesticides examined was the sediment binding pesticides identified in the Regional Board's Phase I monitoring program. This group included pyrethroids (esfenvalerate, permethrin, cypermethrin and lamba-cyhalothrin). These pesticides were targeted as an emerging class of pesticides with increasing use in the Coalition region. General toxicity is listed as a source of impairment in the 303d list and will be a focus of monitoring during Phase I.

The DPR Surface Water Database was searched for records in the four target pesticide categories. Diazinon samples were collected at 39 sites listed in the database. Of the total 1370 individual samples tested for either diazinon or the metabolite diazoxon, 197 (14%) samples contained concentrations greater than 80 ng/l, which is the California Department of Fish and Game Quantitative Response Limit (QRL) guideline for short-term exposure (criteria maximum concentration). The 197 samples with concentrations greater than the guideline occurred at most of the 39 sites sampled. There have been exceedances in all years except 2003. The overwhelming majority of exceedances occurred in samples collected during the winter season, but samples collected during the summer also had exceedances.

Based on the DPR database, chlorpyrifos was monitored at 38 sites in the watershed. A total of 1486 samples were collected and analyzed for chlorpyrifos or chlorpyrifos OA. 147 (9.9%) of the samples had concentrations over 20 ng/l, which is the CDFG QRL for acute exposure. The 147 samples with concentrations that exceeded the guideline occurred at 22 different sites. There was no measured concentration of chlorpyrifos in 1200 samples. There have been exceedances of the chlorpyrifos criteria in the DPR database in almost every year. Exceedances in the database occurred during almost every month of the year. Many of the sample locations are downstream of urban influences and the chlorpyrifos signals at those locations can't be definitively attributed to agricultural sources.

Permethrin was monitored for in 366 water column samples collected from 26 sites. All results were non-detects with a LOQ 0.5 ng/l. Esfenvalerate was tested in 60 samples with all readings listed as non-detects with a LOQ of 50 ng/l at all sites except a single sample with a concentration of 0.0566 µg/l. Cypermethrin and lamda-cyhalothrin were monitored for in 17 samples, all were nondetects.

Table 19. Historical chemical water quality data from the Coalition area.
Programs are only listed from the last 13 years. The list may not be inclusive of every program or study conducted in the Coalition area.

Source	Author	Sample period	Site Name	LAT	LONG	Constituent	Link
DPR		1993	Merced River at Oakdale Road	37.4544	-120.6077	Chlorpyrifos	http://www.cdpr.ca.gov/docs/sw/sitepages/24-1.txt
DPR		1993	Turlock Irrigation Drain #6, 200 yards w of Central Ave	37.4522	-120.5950	Chlorpyrifos	http://www.cdpr.ca.gov/docs/sw/sitepages/24-1.txt
TMDL	JMIE/AEAL	2003	Dry Creek (Tuolumne) at Gallo Bridge	37.6364	-120.9832	Diaz. & Chlorp.	TMDL monitoring by UC Davis
TMDL	JMIE/AEAL	2003	Merced River at River Road	37.3505	-120.9610	Diaz. & Chlorp.	TMDL monitoring by UC Davis
TMDL	JMIE/AEAL	2003	San Joaquin River at Crows Landing	37.4320	-121.0122	Diaz. & Chlorp.	TMDL monitoring by UC Davis
TMDL	JMIE/AEAL	2003	Stanislaus River at Orange Blossom	37.7895	-120.7626	Diaz. & Chlorp.	TMDL monitoring by UC Davis
TMDL	JMIE/AEAL	2003	Tuolumne River at Santa Fe Road	37.6230	-120.8982	Diaz. & Chlorp.	TMDL monitoring by UC Davis
TMDL	JMIE/AEAL	2003	Tuolumne River at Shiloh Road Bridge	37.6033	-121.1306	Diaz. & Chlorp.	TMDL monitoring by UC Davis
USGS	Zamora et al.	2001	Dry Creek (Merced) near Snelling	37.5797	-120.4249	Diaz. & Chlorp.	http://www.cDPR.ca.gov/docs/sw/contracts/USGS_03-4091.pdf
USGS	Kratzer et al.	2000	Dry Creek (Tuolumne) at Claus Road	37.6570	-120.9202	Diaz. & Chlorp.	http://water.usgs.gov/pubs/wri/wri02-4103/wri024103.pdf
USGS	Zamora et al.	2001	Dry Creek (Tuolumne) at Claus Road	37.6570	-120.9202	Diaz. & Chlorp.	http://www.cDPR.ca.gov/docs/sw/contracts/USGS_03-4091.pdf
USGS	Kratzer et al.	2000	Dry Creek (Tuolumne) at Gallo Bridge	37.6364	-120.9832	Diaz. & Chlorp.	http://water.usgs.gov/pubs/wri/wri02-4103/wri024103.pdf
USGS	Kratzer et al.	2000	Highline Spillway to Merced River	37.3875	-120.8036	Diaz. & Chlorp.	http://water.usgs.gov/pubs/wri/wri02-4103/wri024103.pdf
USGS	Kratzer et al.	2000	Livingston Canal at Livingston Tplant	37.4068	-120.7245	Diaz. & Chlorp.	http://water.usgs.gov/pubs/wri/wri02-4103/wri024103.pdf
USGS	Zamora et al.	2001	McHenry stormdrain at Bodem St., Modesto	37.6464	-120.9856	Diaz. & Chlorp.	http://www.cDPR.ca.gov/docs/sw/contracts/USGS_03-4091.pdf
USGS	Kratzer et al.	2000	Merced River at River Road	37.3505	-120.9610	Diaz. & Chlorp.	http://water.usgs.gov/pubs/wri/wri02-4103/wri024103.pdf
USGS	Zamora et al.	2001	Merced River at River Road	37.3505	-120.9610	Diaz. & Chlorp.	http://www.cDPR.ca.gov/docs/sw/contracts/USGS_03-4091.pdf
USGS	Kratzer et al.	2001	Merced River near Stevenson	37.3707	-120.9295	Diaz. & Chlorp.	http://water.usgs.gov/pubs/wri/wri02-4103/wri024103.pdf
USGS	Zamora et al.	2001	Merced River near Stevenson	37.3707	-120.9295	Diaz. & Chlorp.	http://www.cDPR.ca.gov/docs/sw/contracts/USGS_03-4091.pdf
USGS	Kratzer et al.	2000	San Joaquin River at Lander	37.2954	-120.8504	Diaz. & Chlorp.	http://water.usgs.gov/pubs/wri/wri02-4103/wri024103.pdf

			Avenue				
USGS	Zamora et al.	2001	San Joaquin River at Lander Avenue	37.2954	-120.8504	Diaz. & Chlorp.	http://www.cDPR.ca.gov/docs/sw/contracts/USGS_03-4091.pdf
USGS	Kratzer et al.	2000	Stanislaus River at Ripon	37.7300	-121.1094	Diaz. & Chlorp.	http://water.usgs.gov/pubs/wri/wri02-4103/wri024103.pdf
USGS	Zamora et al.	2001	Stanislaus River at Ripon	37.7300	-121.1094	Diaz. & Chlorp.	http://www.cDPR.ca.gov/docs/sw/contracts/USGS_03-4091.pdf
USGS	Kratzer et al.	2000	Tuolumne River at Modesto	37.6272	-120.9864	Diaz. & Chlorp.	http://water.usgs.gov/pubs/wri/wri02-4103/wri024103.pdf
USGS	Zamora et al.	2001	Tuolumne River at Modesto	37.6272	-120.9864	Diaz. & Chlorp.	http://www.cDPR.ca.gov/docs/sw/contracts/USGS_03-4091.pdf
USGS	Kratzer et al.	2000	Tuolumne River at Shiloh Road Bridge	37.6033	-121.1306	Diaz. & Chlorp.	http://water.usgs.gov/pubs/wri/wri02-4103/wri024103.pdf
USGS	Zamora et al.	2001	Tuolumne River at Shiloh Road Bridge	37.6033	-121.1306	Diaz. & Chlorp.	http://www.cDPR.ca.gov/docs/sw/contracts/USGS_03-4091.pdf
DPR		0	San Joaquin River at Lander Avenue	37.2954	-120.8504	Diazinon	http://www.cDPR.ca.gov/docs/sw/sitepages/24-11.txt
DPR		1994	Stevinson Spillway	37.3771	-120.9272	Diazinon	http://www.cDPR.ca.gov/docs/sw/sitepages/24-3.txt
Nawqa		0	Merced River at River Road	37.3505	-120.9610	Field measurements	http://ca.water.usgs.gov/sanj_nawqa/data_sw/swlip.field.html
Nawqa		0	Merced River at River Road	37.3505	-120.9610	major inorganic compunds	http://ca.water.usgs.gov/sanj_nawqa/data_sw/swlip.majors.html
CEPA	RWQCBCVR	1998	San Joaquin River at Crows Landing	37.4320	-121.0122	Metals	http://www.swrcb.ca.gov/~rwqcb5/available_documents/water_studies/SJR.PDF
CEPA	RWQCBCVR	1998	San Joaquin River at Fremont Ford	37.3101	-120.9295	Metals	http://www.swrcb.ca.gov/~rwqcb5/available_documents/water_studies/SJR.PDF
CEPA	RWQCBCVR	1998	San Joaquin River at Hills Ferry	37.3502	-120.9755	Metals	http://www.swrcb.ca.gov/~rwqcb5/available_documents/water_studies/SJR.PDF
CEPA	RWQCBCVR	1998	San Joaquin River at Lander Avenue	37.2954	-120.8504	Metals	http://www.swrcb.ca.gov/~rwqcb5/available_documents/water_studies/SJR.PDF
CEPA	RWQCBCVR	1998	San Joaquin River at Maze Blvd.	37.6412	-121.2276	Metals	http://www.swrcb.ca.gov/~rwqcb5/available_documents/water_studies/SJR.PDF
DPR		2002	Tuolumne River at Shiloh Road Bridge	37.6033	-121.1306	metolachlor/alachlor and deg	2002data_draft AEAL database
Nawqa		0	Merced River at River Road	37.3505	-120.9610	Nutrients and organic carbon	http://ca.water.usgs.gov/sanj_nawqa/data_sw/swlip.nut_orgc.html
DPR		1994	Livingston Spillway	37.4084	-120.7211	OP's	http://www.cDPR.ca.gov/docs/sw/sitepages/24-5.txt
City of Modesto	ATL	0	McHenry stormdrain at Bodem St, Modesto	37.6464	-120.9856	Pesticides	49
DPR		1995	Dry Creek (Tuolumne) at Claus Road	37.6570	-120.9202	Pesticides	http://www.cDPR.ca.gov/docs/sw/sitepages/50-4.txt
DPR		1995	Dry Creek (Tuolumne) at Leask Bridge near Waterford	37.6742	-120.7117	Pesticides	http://www.cDPR.ca.gov/docs/sw/sitepages/50-10.txt
DPR	Bacey	-	Highline Spillway to Merced River	37.3875	-120.8036	Pesticides	74

DPR		0	Highline Spillway to Merced River	37.3875	-120.8036	Pesticides	http://www.cDPR.ca.gov/docs/sw/sitepages/24-4.txt
DPR		0	McHenry stormdrain at Bodem St., Modesto	37.6464	-120.9856	Pesticides	http://www.cDPR.ca.gov/docs/sw/sitepages/50-5.txt
DPR		0	Merced River at Hatfield State Park	37.3508	-120.9606	Pesticides	http://www.cDPR.ca.gov/docs/sw/sitepages/24-6.txt
DPR		1993	Merced River at River Road	37.3505	-120.9610	Pesticides	http://www.cDPR.ca.gov/docs/sw/sitepages/24-7.txt
DPR		1995	Ninth St storm drain at 7th St Bridge, Modesto	37.6303	-120.9936	Pesticides	http://www.cDPR.ca.gov/docs/sw/sitepages/50-6.txt
DPR		1995	Oakdale Irrigation District at Ellenwood Raod near Waterford	37.6733	-120.7733	Pesticides	http://www.cDPR.ca.gov/docs/sw/sitepages/50-11.txt
DPR		0	San Joaquin River at Fremont Ford	37.3101	-120.9295	Pesticides	http://www.cDPR.ca.gov/docs/sw/sitepages/24-9.txt
DPR		0	San Joaquin River at Hills Ferry	37.3502	-120.9755	Pesticides	http://www.cDPR.ca.gov/docs/sw/sitepages/50-29.txt
DPR		0	San Joaquin River at Maze Blvd.	37.6412	-121.2276	Pesticides	http://www.cDPR.ca.gov/docs/sw/sitepages/50-2.txt
DPR		1995	Sonoma Storm drain at Scenic Dr, Modesto	37.6528	-120.9517	Pesticides	http://www.cDPR.ca.gov/docs/sw/sitepages/50-3.txt
DPR		1995	Tuolumne River at Carpenter Rd Bridge	37.6089	-121.0297	Pesticides	http://www.cDPR.ca.gov/docs/sw/sitepages/50-17.txt
DPR		1995	Tuolumne River at Mitchell Rd Bridge	37.6169	-120.9378	Pesticides	http://www.cDPR.ca.gov/docs/sw/sitepages/50-20.txt
DPR	Starner	37439	Tuolumne River at Shiloh Road Bridge	37.6033	-121.1306	Pesticides	76
DPR		2002	Tuolumne River at Shiloh Road Bridge	37.6033	-121.1306	Pesticides	2002data_draft AEAL database
DPR		2002	Tuolumne River at Shiloh Road Bridge	37.6033	-121.1306	Pesticides	http://www.cDPR.ca.gov/docs/sw/sitepages/50-16.txt
DPR		1995	Turlock Irrigation district Ceres Main Spillway	37.6091	-120.9195	Pesticides	http://www.cDPR.ca.gov/docs/sw/sitepages/50-22.txt
DPR		0	Turlock Irrigation District Drain #3 at Jennings Road Bridge	37.5369	-121.0661	Pesticides	http://www.cDPR.ca.gov/docs/sw/sitepages/50-19.txt
DPR		0	Turlock Irrigation District Drain #5	37.4644	-121.0300	Pesticides	http://www.cDPR.ca.gov/docs/sw/sitepages/50-24.txt
DPR		1995	Turlock Irrigation District Hickman Spillway	37.6314	-120.7364	Pesticides	http://www.cDPR.ca.gov/docs/sw/sitepages/50-12.txt
DPR	Bacey	-	Westport Drain at Quisenberry Road	37.5396	-121.0842	Pesticides	74
DPR		2002	Westport Drain at Quisenberry Road	37.5396	-121.0842	Pesticides	http://www.cDPR.ca.gov/docs/sw/sitepages/50-30.txt
DPR		1995	Westside Storm Drain at Neece Dr., Modesto	37.6253	-120.9983	Pesticides	http://www.cDPR.ca.gov/docs/sw/sitepages/50-21.txt
DPR		2002	Tuolumne River at Shiloh Road Bridge	37.6033	-121.1306	pyrethroids	2002data_draft AEAL database

	Don Weston	2003	TID # 3 at Jennings Road (Site 10)	37.5368	-121.0661	Sediment Sampling	data from CVRWQCB
DPR		1995	Tuolumne River at Roberts Ferry Bridge	37.6358	-120.6172	Simazine	http://www.cDPR.ca.gov/docs/sw/sitepages/50-13.txt
ATL		2003	TID # 3 at Jennings Road (Site 10)	37.5368	-121.0661	Toxicity Testing	http://www.swrcb.ca.gov/rwqcb5/programs/irrigated_lands/UCDStudyPlan3-07-03.pdf
DPR		2002	Tuolumne River at Shiloh Road Bridge	37.6033	-121.1306	Triazines/Herbicides	2002data_draft AEAL database

Table 20. Benthic macroinvertebrate bioassessment data from the Coalition area. All data have been collected by UC Davis.

Site Name	Sample Period	LAT	LONG
Bear Creek @ Bert Crane Rd.	2000- present	37.2556	-120.6519
Merced River @ River Rd.	2000- present	37.3497	-120.9578
Ingalsbe Slough @ J17	2000- present	37.4918	-120.5578
Merced River @ J16/Oakdale	2000- present	37.4540	-120.6092
Merced River @ Hwy 59	2000- present	37.4702	-120.5005

Known Water Quality Issues

Eleven water bodies within the Coalition area are listed on the EPA 303d list as impaired water bodies (Table 21). Generally these locations are along the mainstem of the San Joaquin River, but also occur along the lower reaches of the main tributaries. Essentially the entire San Joaquin River through the Coalition area is on the 303d list. Listings include (but are not limited to) numerous constituents from selenium and boron to legacy pesticides (DDT), ammonia, electrical conductivity, and diazinon and chlorpyrifos. Unknown toxicity is also listed as a cause of impairment for several water bodies. Despite the fact that all listed water bodies are located downstream of urban regions known to discharge organophosphate pesticides, metals, and numerous other constituents, municipal discharge is listed as the source of impairment for only one site, Harding Drain. Agriculture is listed as a source of impairment for all sites on the 303d list, and 10 of the 11 sites are listed for either or both chlorpyrifos and diazinon. .

Aquatic assessments performed as part of this program over the past two years indicate that exceedances of water quality objectives have occurred in water bodies within the Coalition area (Table 22). Exceedances for *E. coli*, Specific Conductivity (EC), Total Dissolved Solids (TDS) and toxicity (both sediment and water column) are of particular concern. No relationship was found between region and exceedances due to toxicity. While *E. coli* was observed in nearly all of the subwatersheds, EC and TDS seem to be a problem primarily in the watersheds near the San Joaquin River. Ongoing and proposed assessments are aimed at understanding these water quality issues.

Summary of exceedances of water quality objectives observed in 2004-2005

A complete table of exceedances was included in the semi-annual monitoring report submitted January 3, 2006. We summarize those results below

Pesticides

Two pesticides (diazinon and chlorpyrifos) were detected in 13 samples in the ESJWQC region during the dormant and irrigation seasons of 2005. This is approximately 15 % of the samples tested. Of these, 6 samples had detections of chlorpyrifos exceeding the water quality standards (7%), and 1 sample had a detection of diazinon exceeding the water quality standard (1%). There were no detections of any pyrethroids in the water samples collected for analysis.

Toxicity

Overall, 12 water column toxicity exceedances (4% of all tests) were documented. Seven of these were for *Ceriodaphnia dubia*, and 5 were for *Selenestrum capricornutum*. There were no toxicity exceedances for *Pimephales promelas*. Overall there were 5 sediment toxicity exceedances documented for *Hyalella* survival.

E. coli

Exceedances of *E. coli* standards were the most numerous type of exceedance in the ESJWQC region. There were 41 exceedances that had values above 200 MPN/100 mL and the only subwatersheds that did not have any exceedances were Highline Canal @ Highway 99 and Merced River @ Santa Fe. A proposal is being developed to determine the extent to which *E. coli* may be attributed to agriculture discharge.

Dissolved Oxygen

There were 3 exceedances of dissolved oxygen during the year indicating that dissolved oxygen is not a major water quality issue within the Coalition.

pH

There were 8 exceedances of the pH standard during the year. The majority of these exceedances was within 0.2 pH units from the upper pH limit and thus may not be actual exceedances because meter precision is 0.2 pH units. This indicates that pH is not a major water quality issue within the Coalition.

TDS

There were a total of 13 TDS exceedances all from two subwatersheds, Hilmar Drain and Prairie Flower Drain. All samples collected from Hilmar Drain @ Central Avenue during 2005 had TDS water quality exceedances and six out of the seven collected samples from Prairie Flower Drain @ Crows Landing Rd had TDS water quality exceedances. Although TDS is problematic in these two watersheds, and probably all of the watersheds located close to the San Joaquin River, TDS does not appear to be a widespread water quality issue within the Coalition.

Table 21. Impaired water bodies as listed on the EPA 303d list.

Water Body Type	Water Body Name	Calwater Watershed	Pollutant Stressor	Potential Sources	Estimated Size Affected	Proposed TMDL Completion
R	Harding Drain (Turlock Irrigation District Lateral #5)	53550000				
			Unknown Toxicity	Agriculture	8.3 Miles	
			Ammonia	Municipal Point Sources	8.3 Miles	
			Ammonia	Agriculture	8.3 Miles	
			Chlorpyrifos	Agriculture	8.3 Miles	
			Diazinon	Agriculture	8.3 Miles	
R	Merced River, Lower (McSwain Reservoir to San Joaquin River)	53550000				
			Chlorpyrifos	Agriculture	50 Miles	
			Diazinon	Agriculture	50 Miles	
			Group A Pesticides	Agriculture	50 Miles	
R	Newman Wasteway	54120000				
			Chlorpyrifos	Agriculture	8.3 Miles	
			Diazinon	Agriculture	8.3 Miles	
R	San Joaquin River (Bear Creek to Mud Slough)	53570000				
			Unknown Toxicity	Source Unknown	14 Miles	
			Boron	Agriculture	14 Miles	2003
			Mercury	Resource Extraction	14 Miles	
			Electrical Conductivity	Agriculture	14 Miles	2003
			Chlorpyrifos	Agriculture	14 Miles	2004
			DDT	Agriculture	14 Miles	
			Diazinon	Agriculture	14 Miles	2004
			Group A Pesticides	Agriculture	14 Miles	
R	San Joaquin River (Mendota Pool to Bear Creek)	53570000				
			Unknown Toxicity	Source Unknown	67 Miles	
			Boron	Agriculture	67 Miles	2003
			Electrical Conductivity	Agriculture	67 Miles	2003
			Chlorpyrifos	Agriculture	67 Miles	2004
			DDT	Agriculture	67 Miles	
			Diazinon	Agriculture	67 Miles	2004
			Group A Pesticides	Agriculture	67 Miles	
R	San Joaquin River (Merced River to South Delta Boundary)	54400000				
			Unknown Toxicity	Source Unknown	43 Miles	

			Boron	Agriculture	43	Miles	2003
			Mercury	Resource Extraction	43	Miles	
			Electrical Conductivity	Agriculture	43	Miles	2003
			Chlorpyrifos	Agriculture	43	Miles	2004
			DDT	Agriculture	43	Miles	
			Diazinon	Agriculture	43	Miles	2004
			Group A Pesticides	Agriculture	43	Miles	
R	San Joaquin River (Mud Slough to Merced River)	53570000					
			Unknown Toxicity	Source Unknown	3	Miles	
			Boron	Agriculture	3	Miles	2003
			Mercury	Resource Extraction	3	Miles	
			Selenium	Agriculture	3	Miles	
			Electrical Conductivity	Agriculture	3	Miles	2003
			Chlorpyrifos	Agriculture	3	Miles	2004
			DDT	Agriculture	3	Miles	
			Diazinon	Agriculture	3	Miles	2004
			Group A Pesticides	Agriculture	3	Miles	
R	Stanislaus River, Lower	53530000					
			Unknown Toxicity	Source Unknown	59	Miles	
			Mercury	Resource Extraction	59	Miles	
			Diazinon	Agriculture	59	Miles	
			Group A Pesticides	Agriculture	59	Miles	
R	Tuolumne River, Lower (Don Pedro Reservoir to San Joaquin River)	53550000					
			Unknown Toxicity	Source Unknown	60	Miles	
			Diazinon	Agriculture	60	Miles	
			Group A Pesticides	Agriculture	60	Miles	

Water Body Type Abbreviation: R = Rivers and Streams

Table 22. Water quality exceedances observed at each subwatershed for the first year of Coalition monitoring. An X indicates that there was an exceedance of a water quality objective for that constituent at some point during 2005. For organophosphates, Y denotes detection below the exceedances level.

Watershed	E. coli	pH	DO	EC	TDS	Organophosphates	Water Column Toxicity	Sediment Toxicity
Ash Slough @ Ave. 21	X					X		
Bear Creek @ Kibby Rd	X		X				X	
Cottonwood Creek @ Rd 20	X					Y		X
Dry Creek @ Rd 18	X	X						
Dry Creek @ Wellsford Rd	X	X				Y	X	X
Duck Slough @ Gurr Rd	X							X
Duck Slough @ Pioneer Rd	X					X	X	
Highline Canal @ Highway 99							X	X
Highline Canal @ Lombardy Rd	X	X		X	X	X		X
Hilmar Dr @ Central Ave	X			X	X		X	X
Jones Drain @ Oakdale Rd	X	X	X			Y	X	
Merced River @ Santa Fe	X	X					X	
Prairie Flower Dr @ Crows Landing Rd			X	X	X	Y		X

Potential Water Quality Problems

The Coalition recognizes that organophosphate-caused toxicity will remain a high priority water quality concern. Organophosphates may contribute to water quality impacts during both the irrigation season and during the storm water runoff season following dormant spray applications. Organophosphates will remain on the 303(d) list until such time as it is shown that these constituents are no longer contributing to water quality impacts; therefore, monitoring for these constituents will continue to be required for some time.

As there is a shift in usage from organophosphates to pyrethroid pesticides, the potential exists for the movement of these compounds to water bodies. Due to their extreme affinity for sediments (high K_{oc}), pyrethroids may bind to sediment and contribute to sediment toxicity. If they bind to suspended sediments, they are anticipated to be a cause of water column toxicity. Although analytical techniques for isolation and identification of pyrethroids are being developed, testing water and sediment for these compounds is still problematic and finding laboratories capable of performing these analyses at a reasonable cost may be difficult. The CVRWQCB is taking a leadership role in setting standards for analysis and working with laboratories to develop analytical capabilities.

East San Joaquin Water Quality Coalition Watershed Priorities

Based on the historical water quality problems, exceedances of water quality objectives during the first two irrigation and first dormant season sampling, and current and foreseeable land uses in the Coalition area, the priorities for the Coalition are to:

1. Continue monitoring for those parameters for which exceedances have been found,
2. Determine the cause of any toxicity that is present by a combination of Toxicity Identification Evaluations and analysis of water for specific chemical constituents,
3. Perform studies to identify sources of *E. coli*,
4. Identify the sources of TDS in the watersheds close to the San Joaquin River,
5. Implement outreach programs aimed at reducing delivery of constituents to the water bodies in the Coalition area.

As required by the MRP, all growers living in watersheds that have experienced exceedances will receive a letter from the coalition indicating that there have been exceedances discovered and providing the nature of those exceedances. We have developed a list of names and addresses of the growers from the parcel numbers in the watersheds and the pesticide use reports. Meetings will be scheduled and all growers will be encouraged to attend. At the meetings, the SJCDWQC will circulate the BMP survey(s) to growers so that we can inventory the management practices used. We are attaching a draft survey below that will be given to orchard growers, and we are in the final stages of developing surveys for additional crops.

In addition, to focus our management outreach efforts for *E. coli*, we have proposed a source identification study and the coalition is currently developing the study design.

East San Joaquin Water Quality Coalition Management Practices

Implementation Plan

BMPs

In a July 2004 response to staff comments on the April 1, 2004 Watershed Evaluation Report and the Monitoring and Reporting Project Plan submissions, the ESJWQC submitted a BMP compilation for the major crops grown in the coalition region (alfalfa, apples, cherries, corn, dry beans, peaches, tomato, walnuts, wine grapes). The compilation is provided below in Appendix 1. These are management practices that are currently employed by growers to guide farming operations in the coalition region. Although growers may not use all of the management practices listed in the compilation, they select each year those practices that will result in maximizing their yields while protecting water quality. In addition, growers applying agricultural chemicals follow the label instructions on the product as their first management practice to prevent off-site movement of the chemical.

Understanding the specific management practices used by growers in any watershed is a goal of the coalition's outreach and education activities. The results of the current year's monitoring activities will guide the targeting of coalition efforts in surveying the management practices used in watersheds, specific TRS', and by individual growers. We have a series of meetings scheduled in several large watersheds, and will hold additional meetings at the level of the monitoring watershed to address specific exceedances. At that time, we will be able to compile an inventory of BMPs used in those watersheds. It must be emphasized that the management practices that growers indicate they use may in fact not have been used in the past year, or may not be used next year depending on the specific weather conditions and pest outbreaks. And, specific management practices may vary across single fields depending on soil conditions, drainage, and nutrient retention capacity (cation holding capacity). Consequently, trying to relate specific management practices to specific exceedances will be difficult. However, there are management practices dealing with pesticide applications that should be implemented regardless of the weather, soils, or drainage. We will be able to determine the application procedures and report those results. We will compile all results and provide that compilation in the June 30, 2006 report.

Pesticides

The Coalition has obtained parcel level information from the counties within the Coalition region. Currently we have information on crop acreages by watersheds from the Department of Water Resources database. These data are several years old and we are attempting to update our crop data through county records. We have requested

Pesticide Use Reports (PUR) from all counties in the Coalition region through September 2005. Stanislaus County expects that August and September should be available by April 2006. PURs are filed by township-range-section, not by parcel. Consequently, it is often difficult to assign a specific pesticide application to a parcel within a section of land. Finally, on the PUR entries, common name, trade name, or chemical number are used to reference a single chemical. The Coalition is developing an inventory of crops by fields, BMPs used on those crops, and the location of any field drains that can be identified

Actions to date include eight meetings with growers (Table 23) over the last calendar year. These meetings presented the goals of the Conditional Waiver Program, the monitoring results from the coalition's and the Regional Board sampling programs, and provided growers with an introduction to implementation of management practices. The last three meetings have been annual meetings held in Stanislaus, Merced, and Madera Counties. At that meeting, the monitoring results were presented, and the management practices that can be used were introduced.

Table 23. Landowner/Grower outreach meetings conducted in the coalition region during the 2005 calendar year.

Date	Meeting	Number of Attendees
Feb.15, 2005	ESJ presentation on monitoring results/orchard BMP review at grower meeting, UC Cooperative Extension sponsored, Madera	70
February 22, 2005	ESJ presentation on monitoring results/orchard BMP review at Turlock Irrigation District grower meeting, Turlock	60
March 9, 2005	ESJ presentation on monitoring results/orchard BMP review at Merced County Ag Commissioner continuing education meeting, Merced	60
March 21, 2005	Presentation on ESJ monitoring results, BMP implementation to board of directors, Red Top Resource Conservation District, Chowchilla	10
March 24, 2005	ESJ Workshop: monitoring results review: orchard, row crop BMP review, Modesto	55
November 8, 2005	ESJ Annual meeting: review of 2005 sampling results, review BMPs for orchard/row crops, Modesto	140
November 30, 2005	ESJ Annual meeting: review of 2005 sampling results, review BMPs for orchard/row crops, Madera	50
December 8, 2005	ESJ Annual meeting: review of 2005 sampling results, review BMPs for orchard/row crops, Merced	55

Types of Management Practices

Obtaining information on management practices was addressed in the March 11, 2005 memo to the Regional Board and is provided below.

A software program to compile BMPs of coalition members is in the process of being develop through a PRISM grant managed by the Coalition for Urban Rural Environmental Stewardship. This software will be provided free to coalitions groups for use in their data management systems.
Timeline: The first draft of the software was expected to be completed by July 2005. Delays have occurred and we now anticipate that this software will be available by May or June 2006. The Coalition will receive the software shortly thereafter. Data entering from the above surveys will begin immediately with totals and data analysis completed by December 2006.

Types of Pesticides

We have queried all counties in the Coalition region and have obtained, or will shortly obtain, pesticide use reports for all monitoring to date. We are currently working through the databases available, and will continue to work through the databases to characterize pesticide use in watersheds with water quality exceedances.

Subwatershed Outreach Efforts

The first phase of the Coalition's Implementation Plan is already underway. Efforts to-date include organizational activities, data purchase, database creation and validation, direct mailings, and presentations at irrigation district meetings and at commodity group meetings. This first phase has been directed at 1) understanding the waiver requirements and navigating the changing Ag Waiver process, 2) evaluating alternative methods for raising the funds necessary to carry out the program, and 3) "getting the word out" to affected landowners.

Outreach to landowners and operators will be performed through various activities including grower meetings and workshops, articles in newsletters and trade press, Coalition websites postings and mailings to coalition members. Outreach will generally be performed at a subwatershed level. During the next year, outreach and BMP implementation efforts will include:

- Fostering landowner/operator identification with subwatershed groups
- Obtaining affirmative opt-in notifications from affected landowners and operators
- Communicating with landowners and operators about options provided under the conditional waiver

- Communicate results of last year's water quality monitoring to landowners and operators
- Communicating potential water quality concerns and technical resources available to address those concerns to the landowners and operators

Implementation Outreach and Tracking

The Coalition recognizes that the focus of its efforts should be on encouraging its members to implement on-the-ground practices to reduce water quality impacts. The tracking of implementation combined with assessment of water quality will provide information to help evaluate management practice effectiveness and to identify areas where additional implementation efforts may need to be pursued. The precise model for tracking implementation has not yet been developed. Additional outreach to growers will provide the Coalition with information necessary to select the most appropriate and effective methods to encourage and track implementation; however, the following methods are being considered and will to some degree be a part of the implementation effort conducted by the Coalition:

- Landowners or operators at the county agricultural commissioner's office or with the NRCS may file "On-Farm Practices" information sheets.
- Workshops will be held at which farmers may develop their own conservation plans, with the technical assistance of RCDs, NRCS, UC Cooperative Extension and other groups and agencies, commodity groups or farm input suppliers. These types of "farm water quality short course" programs have been State-funded in the Imperial Valley and on the Central Coast, and the Coalition intends to pursue grant funding to expand these workshops into the Coalition area.
- GIS mapping will present a graphic display of management practices implementation throughout a subwatershed.

The Coalition will use its GIS capabilities to map and track the progress of water quality management practices. The Coalition and its Subwatersheds will approach tracking water quality issues related to irrigation return flow discharges separately from storm water discharges.

Communication of Water Quality Results

Monitoring results that indicate exceedances of water quality objectives will be communicated to landowners/operators. The Coalition's role is to provide information about water quality problems and work to solve those problems. Depending on the causes of exceedances, solutions could include a targeted outreach program to landowners/operators adopting best management practices or modifying uses of specific farm inputs to prevent movement of the constituent of concern into the impacted surface water. Details on the Coalition's response to exceedances are described in the MRP and an outline of actions within specific subwatersheds is listed below in a three-phase approach.

Phased Approach

If actionable toxicity or an exceedance of a state or federal standard is detected at a monitoring site, the Subwatersheds will address the problem using a three-phased approach. The approach represents a framework for implementing the Response Plan as described in the MRP.

Pesticides

Phase I

1) Contact landowners in the impacted Subwatershed or drainage via email, mailed correspondence, or regular irrigation district and commodity group newsletters. The following information will be provided:
    - Identification of the constituent detected (pesticide, nutrient, sediment, etc.);
    - Identification of the potential lands in the subwatershed that could contribute to runoff;
    - Identification of the potential crops where the constituent could have been applied (or could have originated);
    - A plan for action, developed by coalition cooperating entities that includes a list of potential BMPs, time frames for implementation and information on agencies or resources to assist in adopting BMPs. A template implementation plan for the specific constituent causing toxicity will be developed by the Coalition technical committee, and if necessary, revised to meet the individual needs of subwatersheds.
    - A description of potential actions that local or state regulators could take if subsequent monitoring does not show mitigation of the toxicity.
2) Organize Outreach meetings in the effected subwatershed or drainage
    - Landowners and operators will also be informed of the monitoring results through outreach meetings or presentations held in the subwatershed or drainage areas and organized by the subwatershed and cooperating entities. The same information described in 1) will be covered in presentations and handout materials.

Phase II

If successive monitoring results show ongoing toxicity or no improvement in discharge levels for constituents of concern, Phase II of the plan will be implemented. Phase II includes continued landowner outreach describing monitoring results and promotion of BMPs to mitigate the problem as described in Phase I.

In addition, the Coalition or its Subwatershed may request the implementation of a mandatory Product Stewardship Program. This program, lead by the County Agricultural Commissioners, the California Department of Pesticide Regulation and pesticide registrants and suppliers, consists of working with landowners/operators on the development and implementation of BMPs that are specific to a product's use.

Phase III

If additional monitoring results show no improvement in toxicity or pesticide levels, the Coalition or its Subwatersheds may recommend to the County Agricultural Commissioners that actions such as localized permit conditions be developed and implemented to prevent movement of the pesticide into local waterways. The coalition may also recommend to DPR that the product be considered for a formal Product Reevaluation

Other Constituents

Phase I

(Same as Pesticides)

Phase II

If successive monitoring shows no improvement in an identified problem discharge, then phase II will be implemented. Phase II may include a focused outreach program in the area led by the Coalition or its Subwatersheds and those entities with expertise on BMPs such as NRCS, UC Extension, RCDs and CURES. This outreach and BMP implementation will concentrate on areas identified to be associated with the discharges and will involve working with Landowners and Operators to implement programs to address those concerns.

The soils found in the identified area should be investigated to see if they have high leaching and runoff indices. A good natural resources inventory of the identified area should be conducted as one of the first phases of the conservation planning process. There might be other factors besides soils that contribute other constituents of concern, such as slope or a higher rainfall area.

Phase III

If additional monitoring results show no improvement in problem discharges, then Phase III will be implemented. Phase III will recommend that landowners develop a Farm Conservation Plan or similar plan designed to address the specific constituent. The affected landowners will be encouraged to work with NRCS and associated entities to develop and implement the plan.

Communication of Water Quality Results with the Regional Board

Exceedance Reports
In accordance with the August 15, 2005 MRP, any evidence of statistically significant toxicity or the identification of a specific chemical constituent in surface water in exceedance of an established water quality standard will trigger an Exceedance Report to the Central Valley Regional Water Quality Control Board (CVRWQCB). The Exceedance Report will be submitted to the CVRWQCB in the form of an email and will be submitted within 1 day following sampling or of the receipt of results. Exceedances involving field parameters will be reported within 1 day after sampling, and all exceedances of constituents analyzed by the laboratories (toxicity, drinking water

parameters, and physical/chemical constituents) will be reported 1 day following receipt of the results from the laboratory.

Communication Report
In accordance with the August 15, 2005 MRP, a Communication Report will be submitted 45 business days following submission of the Exceedance Report. Each Communication Report will include a description of the follow-up monitoring and analyses that were conducted, actions taken to identify the sources of the exceedance(s), complete analytical results if available (if not available, a time schedule for delivery of the analytical results will be provided), and time schedules for delivery of the Management Practices Effectiveness information and the Evaluation Report.

Evaluation Report
In accordance with the time schedule established in the Communication Report, an Evaluation Report will be submitted. The Evaluation Report will include a description of the management practice(s) implemented and the chemicals/constituents targeted by the management practice(s), the reasons for implementing the specific practice(s), the methodology employed to evaluate the effectiveness of the practice(s), and the involvement of the stakeholders in evaluating the practice(s).

Appendix 1. Crop-specific BMPs

Crop: Alfalfa		
Compilation of Best Management Practices to Protect Surface Water from Farm Runoff		
Pesticide Application BMPs		
In-Season Sprays		
Improved Monitoring	Improved monitoring can lead to reduced sprays through "spray when necessary" rather than "calendar" timing. Alfalfa serves as a reservoir for a great variety of natural enemies that move from the hay fields to other plantings such as cotton, melons, and beans; these insects are thus significant factors in helping to control pests in many other crops.	
Organophosphates	Benefits	Excellent control of targeted insects.
	Drawbacks	Easily transported in water. Somewhat hard on beneficials though not to the same degree as pyrethroids.
Pyrethroids	**Benefits**	Excellent control of targeted insects. Not easily transported in water since they attach easily to soil particles
	Drawbacks	Resistance occurs quicker in pyrethroids than other classes of chemicals. Hard on beneficials leading to secondary pest outbreaks, especially aphids. Highly toxic to fish in solution. Can be transported off-site with sediment during rainfall or irrigation events.
In-Season Spray BMPs		
Insecticides & Herbicides		

<table>
<tr><td>Drift</td><td colspan="3">The ability to detect products in streams and rivers at parts per trillion levels leaves little room for error.
To prevent problems, equipment operators must take extra care when spraying near sensitive areas and bodies of water.
Shutoff equipment near windrow ends.
Avoid applying when wind is blowing toward waterways or other sensitive areas.
Leave buffer zone to protect sensitive areas.
Use of larger droplet sizes.
Use of drift retardant chemicals in the spray mix. Although these are effective in reducing the number of drift-prone droplets, in most cases it is more effective to select the proper size and type of nozzles and operate sprayers at low pressure to produce the desired drop size, rather than attempt to increase droplet size with drift retardant chemicals.</td></tr>
<tr><td colspan="4">Alfalfa Field Practice BMPs</td></tr>
<tr><td rowspan="2">Cultural Practices</td><td>Strip Cutting</td><td colspan="2">Harvesting alfalfa by cutting alternate strips benefits hay production by maintaining populations of predators and parasites of alfalfa pests within the alfalfa field. In addition, strip-cutting also markedly reduces lygus bug migration into cotton and other crops.
Similar benefits can be obtained by staggering the cutting of alfalfa hay fields that are nearby or adjacent to each other. Lygus bugs and natural enemies will migrate from cut to uncut alfalfa fields.
Large alfalfa fields that are broken up into alternating irrigation and cutting cycles also maintain populations of predators and parasites, as well as lygus, within the alfalfa field.</td></tr>
<tr><td>Border Cutting</td><td colspan="2">If strip-cutting is impractical, retention of natural enemies may be promoted by leaving 10-foot, uncut strips of hay on alternate irrigation levees (borders). Uncut strips left at one harvest are cut at the following harvest, and strips are then left on the previously clean-cut levees. This technique also promotes the retention of lygus bugs within the alfalfa hay field.</td></tr>
<tr><td rowspan="3">Irrigation Runoff Management</td><td rowspan="2">Catchment basins</td><td>Benefits</td><td>Catchment basins with tailwater return systems can alleviate excess runoff preventing runoff from moving into surface waters.
Water savings</td></tr>
<tr><td>Drawbacks</td><td>Unlined catchment basins can contribute to downward movement of pesticides towards groundwater, so design is very crucial.</td></tr>
<tr><td>Improved soil monitoring</td><td colspan="2">Timing of irrigations is important so that moisture levels are not too high when irrigations occur, allowing for increased infiltration.</td></tr>
</table>

	PAM Applications	PAM is a polymer compound injected or fed into irrigation water at the head of a field supply ditch or discharge point. Applications rates range from 5-8 pounds per acre with the material typically metered into the head ditch with a gandy-type applicator	
		Benefits	In newly formed furrows, soil does not move down the row or erode when irrigation water is treated with PAM. Suspended soil particles drop out of irrigation water containing PAM. After an irrigation containing PAM, furrow erosion and transport of sediment is greatly reduced in subsequent irrigations. Erosion reductions of 95% have been documented in numerous field trials and commercial applications in the San Joaquin Valley.
		Drawbacks	Additional cost (especially with frequent irrigations of alfalfa). Is not effective in preventing solubilized pesticides from moving off-site.
	Sprinklers	Amount of water can be controlled and therefore runoff is more easily controlled.	
Vegetative Buffers	Areas or strips of land surrounding a field that are maintained in permanent vegetation. To effectively trap pesticides, buffers must slow water runoff and increase infiltration so that pesticides can be trapped and degraded in buffer soil and vegetation. Vegetative buffers are a tool to further improve water quality and provide additional benefits such as wildlife habitat and stream bank protection. For best success, they should be used in conjunction with other mitigation practices.		
	Benefits	Can be used to manage soil, water, nutrients and pesticides while minimizing environmental impacts. Effective in trapping eroded sediment, reducing runoff of pesticides that are adsorbed to soil particles. Note: some pesticides (e.g. OPs) are highly water soluble and don't adsorb to soil particles as readily as others (e.g. pyrethroids).	
	Drawbacks	California-based research is limited on the potential for filter strips and grassed waterways to reduce OP pesticide loading, although the practices have been shown to be effective in other regions of the U.S. Uncertainties of buffers include: appropriate dimensions for volume of water flow; appropriate plant species and plant density for the soil types and rainfall zones; considerations for various locations; slope and channel dimensions for grassed waterways; and dimensions for constructed wetlands. Can require growers to set aside productive acreage.	

Vegetative Filter Strips	Areas of grass or other permanent vegetation used to reduce sediment, organics, nutrients, pesticides and other contaminants in runoff to maintain or improve water quality. Vegetative filter strips are located between crop fields and water bodies, i.e. grassed roadways. Plant material captures rainfall and retains nutrients. Roadways can be grassed or sod planted, as can sprayer mixing pads and wellheads. Depending upon the site, a full border around a field may not be necessary for mitigating impacts to surface water. Filter strips could be planted at tail ends of fields or in other critical zones.	
	Benefits	Slows runoff allowing sediment to drop out of suspension. Traps sediment with adsorbed pesticide residues. Increases water infiltration into the soil profile. Catches some pesticide drift, preventing it from reaching the soil.
	Drawbacks	If water runoff is channeled, a grass strip may not effectively trap the adsorbed pesticides.
Grassed Waterways	Natural or constructed channels planted in permanent vegetation and located in an area where runoff concentrates. Constructed waterways can be graded to carry surface water at a non-erosive velocity to a stable outlet. Waterways are most effective in trapping sediment and dissolved chemicals when designed to spread concentrated water flow evenly cross a vegetative filter adjacent to waterways.	
	Benefits	Helps slow the flow of water to a non-erosive level. Provides a means of trapping sediment, nutrients, and pesticides while preventing gully erosion. Provides habitat and cover for wildlife.
	Drawbacks	Overgrown channels causing waterway breaching and flooding can restrict storm flows. Due to the concentrated flow that normally occurs in waterways, sediment trapping and water infiltration can be minimal with large runoff events, but substantial with smaller events.
Filter Ditches	Areas filled with activated charcoal, peat, or other filtering agents at locations where water leaves the ranch. These would be replaced periodically and would filter pesticides before the soil solution reaches surface water.	
	Benefits	Further research is needed in California but other areas of the US have shown effective reduction of pesticide residue.
	Drawbacks	High cost due to materials and increased maintenance needed.
Riparian Buffers	Trees and shrubs planted adjacent to streams, lakes, ponds and wetlands. Forest buffers are frequently combined with an understory of perennial grass buffers.	

	Benefits	Helps lower water temperatures by shading the water body. Protects stream banks and slows out-of-bank flood flows. Deep tree roots may intercept nitrate entering streams in shallow subsurface flow and provide soil carbon for microbial energy. Microbes can denitrify nitrate and degrade pesticides. Woody vegetation provides food and cover for wildlife. Contributes energy sources to aquatic communities.
	Drawbacks	If water runoff is channeled, riparian buffers may not effectively trap pesticides.
Constructed Wetlands	Wetlands constructed at tile outlets or as part of riparian buffer systems for degrading pesticides and denitrifying nitrates.	
	Benefits	Provides confined area for breakdown of pesticides in water.
	Drawbacks	Land needed for constructed wetlands is not readily available in high production areas. Available land can be costly.
Hedgerows	Fences of shrubs or trees in, across, or around a field. Hedgerows can include an understory composed of perennial native grasses and forbs, a shrub midstory composed of California native species and occasionally a discontinuous overstory of valley and foothill trees.	
	Benefits	May reduce erosion by having perennial vegetation on a portion of the field. If runoff flows across the hedgerow in sheet flow, sediment can be trapped, reducing the amount of sediment and sediment-borne pesticides from entering surface waters. Can attract beneficial insects and provide competition against invasive weeds. Windbreaks and hedgerows can provide drift mitigation, potentially reducing off-site movement of pesticides. Because many of the native species used in hedgerows have deep roots that hold the soil and increase water permeability, there may be a reduction in water runoff and off site movement of sediment. This could reduce runoff of pesticides in the dissolved and sediment-borne phases of field runoff. However, no studies have quantitatively measured the reductions in OP pesticide runoff.

	Drawbacks	Certain plant species may attract pests that can attack the crop or neighboring crops. Careful consideration must be given to the species of vegetation selected and the types of insects that may be attracted. Plant species can provide habitat and attract endangered species. Safe Harbor Agreements are available to protect growers where a practice is implemented that could attract endangered species to their farms, a factor that should be evaluated and addressed before establishing hedgerows. Some species can grow 10-15 feet wide, so space must be allowed for equipment to pass.
Stewardship BMPs		
Mixing / Loading/Cleanup		
Concrete or Asphalt Pad	Use concrete or asphalt pad that drains to a central sump	
Proximity of mixing/loading area	Take precautions to insure that the minimum distance between any mixing/loading area and any ditches, canals or streams that feed into nearby rivers is at least 100 feet. Take precautions to insure that the minimum distance between any mixing/loading area and pump is at least 100 feet.	
Equipment	Check equipment for cracked / broken hoses, valves, etc. Calibrate prior to each application. Use spray nozzles with large droplet size to minimize drift.	
Tank filling	Fill tank to 1/3 to ½ full prior to the addition of chemicals. Use air gap to prevent tank overfilling. Use backflow valve on the fill tube.	
Personnel	Person(s) always present during mixing/loading operations. Person(s) trained to take corrective action when necessary.	
Storage Areas	Have spill containment capability to protect from runoff into any nearby surface waters. Use impermeable surface (coated or sealed concrete) with curbs for floors.	
Cleanup	Mix rinseate with water and reapply to field. Clean equipment on appropriate pad at least 300 feet from surface waters. Triple rinse empty containers and dispose of in landfill or recycling area.	
Nutrient/Fertilizer Application BMPs		

Soil, Tissue and Water Testing	Base N fertilizer amount and timing on crop needs and production goals. Before applying N early in the growth cycle, assess the amount of nitrate already present by soil (or soil solution) sampling and analysis. Use plant tissue sampling for mid- and late season fertilizer decisions. Measure nitrate levels in the irrigation water and adjust N fertilizer rate accordingly.
Application Timing	Determine the amount of nitrate already present in the soil. Apply N, P and K at a rate consistent with the crop nutrient requirements. Split applications of N fertilizer. Do not apply excessive single amounts of fertilizer N during the rainy season. For fertilizer application during fall, use only low N-containing materials such as N:P2O5:K2O equal to 1:3:3. Higher N materials may be appropriate if a crop is to be planted soon.
Fertilizer Placement	Place N fertilizer materials where maximum plant uptake will occur.
Irrigation	Adopt sprinkler irrigation. If fields are more than 1000 feet long, consider cutting the run length in half with a corresponding decrease in set time. Use high flow rates initially to get water down the field and then cut back to finish off the irrigation. Avoid doing the opposite. Collect surface water runoff for recirculation or reuse in other fields.
Application Practices	Clean-up fertilizer spills promptly. Shut off fertilizer applicators during turns and use check valves when possible. Maintain proper calibration of fertilizer application equipment. Whenever injecting fertilizer into irrigation water, ensure backflow does not occur. Rinse water from fertilizer tanks should be evenly spread throughout a field. Fertilizer tanks and equipment should be cleaned by rinsing in the field or at a properly designed wash facility. Rinse water and/or sludge should be evenly spread across a field using good agronomic practices. When equipment is parked, use care to prevent material from leaking into storage area. If equipment is known to be in disrepair, completely remove fertilizer material before parking equipment. When transferring fertilizer into on-farm storage or into a fertilizer applicator, take care not to allow materials to accumulate on the soil. Good housekeeping practices should be implemented to prevent contamination of groundwater and/or surface water.
Sediment Control BMPs	
Water and Sediment Control Basins	Constructed earth embankments or a combination ridge and channel. Constructed across the slope and minor watercourses to form a sediment trap and water detention basin.

	Benefits	Trap sediment and pesticides adsorbed to soil particles. Reduce and manage onsite and downstream runoff. Divert the flow of dissolved substances such as nutrients and pesticides. Improve the farmability of sloping land, reduce water course and gully erosion. Improve downstream water quality.
	Drawbacks	Basins are not viable for many orchard areas in California, primarily because considerable land acreage would be required to manage the volumes of water typically produced in rainfall events, especially in the Sacramento Valley.
PAM Applications	PAM is a polymer compound injected or fed into irrigation water at the head of a field supply ditch or discharge point. Applications rates range from 5-8 pounds per acre with the material typically metered into the head ditch with a gandy-type applicator	
	Benefits	In newly formed furrows, soil does not move down the row or erode when irrigation water is treated with PAM. Suspended soil particles drop out of irrigation water containing PAM. After an irrigation containing PAM, furrow erosion and transport of sediment is greatly reduced in subsequent irrigations. Erosion reductions of 95% have been documented in numerous field trials and commercial applications in the San Joaquin Valley.
	Drawbacks	Additional cost Is not effective in preventing solubilized pesticides from moving off-site.
Tailwater Return Systems	Benefits	Use of tailwater can offer substantial savings in irrigation power consumption if the water supply is groundwater. A tailwater recovery system increases yields because of higher irrigation efficiencies. A tailwater recovery system will not save all the tailwater, but it can increase irrigation efficiency by 25 to 30 percent.
	Drawbacks	The loss of the area required for a reuse pit and periodic maintenance of the pump, storage and return facilities.
Compaction / Wheel Rutting	Wheel ruts formed by equipment passing through wet fields can create channels for water and sediment to runoff from orchards. Where possible, minimize creation of wheel ruts with dormant orchard sprayers, brush shredders or other equipment when orchard floor is saturated.	
Drainage System Management	Filtering runoff water through vegetation allowed to grow in drainage ditches may help mitigate offsite movement of sediment as well as pesticides dissolved in storm runoff.	
Avoiding Channelization of Streams and Creeks	Allowing streams to naturally flow and meander can increase runoff retention and infiltration. A modified or channeled stream could also be restored to a more natural state by re-establishment of the riparian vegetation, which also provides stream bank protection.	

Berms at Low Ends of Fields (sandy soils, low slope)	Raised berms at low ends of fields can trap sediment and adsorbed pesticides reducing runoff of dissolved substances in fields with low slopes and sandy soil types. Berms hold back water, increasing runoff retention and allowing infiltration.	
Aeration	Use of specialized tillage equipment to break crusts and aerate soils with the intent of increasing water penetration and retention, thus reducing runoff. Aeration improves the soil profile with minimal disruption to the floor if completed during dormant season. Aeration may reduce OP pesticide runoff although no studies have been conducted.	
Improving soil texture (tilth)	Practices such as gypsum (or sulfur in higher lime soils) and humic acid applications or actions of earthworms have potential to increase water penetration and reduce runoff in compacted soils or where an impermeable soil layer exists. However, no studies have been conducted to show efficacy in reducing OP pesticide runoff with these approaches.	
	Benefits	Increased water penetration resulting in less runoff and increased recharging of the soil profile. Less water runoff means less potential for pesticides to be transported off-site.
	Drawbacks	Results vary with soil type and, under some conditions, compaction could increase. Improved soil permeability may increase movement of nitrate and other chemicals into groundwater. The balance of benefits versus disadvantages is not clear at this time and more research is needed.

Reference:

Integrated Pest Management for Alfalfa Hay: University of California Statewide IPM Project. 1981. 98pp.

http://ipm.ucdavis.edu/PMG/selectnewpest.alfalfa.html

Mixing and Loading Crop Sprayers, Tips and Techniques, Protecting Water Quality: Coalition for Urban/Rural Environmental Stewardship (http://www.curesworks.org)

Field and Row Crop Sprayers, Tips and Techniques, Protecting Water Quality: Coalition for Urban/Rural Environmental Stewardship (http://www.curesworks.org)

Crop: Apples	
Compilation of Best Management Practices to Protect Surface Water from Farm Runoff	
Pesticide Application BMPs	
Dormant Season Sprays	
Monitoring	Improved monitoring can lead to reduced sprays through “spray when necessary” rather than “calendar” timing. Dormant - Monitor for mite eggs, aphid eggs, San Jose scale Pre-bloom - Examine shoots for aphids, leafrollers/fruitworm/pandemis/tussock moth caterpillars - Monitor weather for conditions favorable to scab, powdery mildew, bacterial blast Bloom - Monitor weather for conditions favorable to scab, fireblight, bacterial blast, powdery mildew - Set out and monitor codling moth traps - In mating disruption orchards, put pheromone dispensers out at biofix - Continue to examine shoots and bloom for aphids Base treatment decisions on monitoring of the field.
Dormant Diazinon and Oil Spray	Diazinon combined with dormant oil during the dormant season. Diazinon applications are frequently alternated with non-OP pesticides to prevent resistance from developing to either diazinon or non-OP pesticides. Information is being developed on earlier timing of winter OP applications when less rainfall is likely or when the rainfall is more likely to be absorbed into the soil rather than runoff. Reduced rates: additional data is needed to demonstrate effects at varying pest densities.
No Dormant Treatment or Dormant Oil Only Treatment	Dormant insecticide spray is not applied or an oil only treatment is made. Skipping dormant insecticide sprays has been successful when pest pressure is low or non-existent.
Alternate Year Dormant OP Pesticide With Yearly Oil Spray	Use dormant OP every other year but use dormant oil on an annual basis. In years with no dormant OP used the following may be necessary: - Additional in-season treatments. - Additional in-season treatments for mites are possible following in-season applications of carbaryl, esfenvalerate and permethrin.

Delayed Dormant Treatment	Delayed dormancy is the period from the resumption of growth, indicated by bud swell until green tip. The delayed dormant application should control woolly apple aphids. A summer application (late July to August) will only be required if the parasites are disrupted. Foliage treatments may be necessary for young trees with severe infestations.
Dormant Spray (Non-OP Pesticides) and Oil	Pyrethroids (permethrin and esfenvalerate) and carbamates (carbaryl) in the delayed-dormant or dormant season. Residues of the pyrethroid insecticides permethrin and esfenvalerate persist on bark and may impact naturally occurring predator mites for extended periods of time after dormant season and in-season applications. Mite outbreaks caused by use of pyrethroids may require additional miticide treatments over and above those normally applied. In general, insects become resistant to pyrethroids more rapidly than other classes of pesticides. Some registered products are not widely used in the dormant season because of possible effects on non-target organisms or because of label restrictions. For example, carbaryl cannot be used in orchards where honeybees are present and endosulfan use is restricted near water or wetlands. Non-OP pesticides can affect non-target organisms in water and the potential for offsite movement from runoff has not been well studied. If a non-OP pesticide is applied as a dormant spray, precautions such as on-site practices (following sections) should be taken to prevent movement into surface waters. Laboratory exposures indicate that fish and invertebrates are particularly sensitive to pyrethroids. Pyrethroid persistence may mean that they will be transported off site. If so, they may be bioavailable to fish in water or to invertebrates in sediment. Sediment toxicity may result after pyrethroids are transported into water bodies.
Pheromone Mating Disruption for Codling Moth	Mating disruption relies on releasing pheromones through dispensers distributed throughout an orchard or applied as a spray. Mating disruption is most successful in uniform orchards on flat ground with relatively low codling moth populations. In orchards with moderate to high populations and/or in the first year of mating disruption, insecticides or other supplemental controls will likely be needed in addition to the mating disruption program. Pheromone mating disruption cannot be considered a stand-alone system. It is selective for the target pest so monitoring for other orchard pests as well as codling moth is necessary.
Dormant Season Spray BMPs	

Restrict dormant spray applications (except oil alone) to ground applications only. Do not apply within 100 feet upslope of any sensitive aquatic site that may drain into a river or tributary unless runoff is contain or diverted from the sensitive aquatic site. Waters that are contained or diverted must be held for 72 hours before they can be released into a sensitive aquatic site. Maintain a vegetative buffer strip a minimum of 10 feet wide from the edge of the field to sensitive aquatic sites. Do not apply dormant sprays (except oil alone) when soil moisture is at field capacity and a storm is predicted in the next 48 hours. Do not apply dormant sprays (except oil alone) when surface runoff to sensitive aquatic sites from a rain event could occur within 48 hours after the application. Make dormant applications only when insect-scouting information indicates pest populations have reached damaging levels. (See University of California Integrated Pest Management Guidelines for apples.) Apply only when wind speed is 3-10 mph at the application site as measured by an anemometer outside of the orchard on the upwind side. When air currents are moving (>3 mph) toward sensitive aquatic sites, commence applications on side nearest the site and proceed spraying away from the water body. Spray last three rows upwind of bodies of water using nozzles on one side only, with spray directed away from sensitive aquatic sites. Reduce the maximum rate of application and the number of applications. Alternate the dormant use of organophosphorous and pyrethroid insecticides with other environmentally reduced risk pesticides or make application in season according to University of California Integrated Pest Management recommendations.	
Dormant Orchard Field Practice BMPs	
Orchard Floor Vegetation During Dormant Season	Seeded or resident vegetation growing on orchard floors that is later mowed or disked. Resident Vegetation - existing, unplanted mixture of annual or perennial weeds, crop species and/or native grasses and forbs which has adapted to management methods used in the orchard. Seeded vegetation - cover crops that include many types of cultivated species including legumes (bell beans, peas, clover, medics and vetches) and grasses such as cereal grains, turf grasses and sudan grass.

	Resident or Seeded Vegetation (continued)	**Benefits**	Orchard floor vegetation can reduce dormant spray pesticide runoff to surface waters in several ways: - Can be easily encouraged to grow in the fall or early winter by a post harvest irrigation or early rains and requires little to no management to establish. - Reduction in runoff volume through increased water infiltration. - Reduction in sheet erosion caused by rainfall impact on bare ground. - Decrease in pesticide mass carried by sediment. - Shorter pesticide persistence (faster breakdown) on vegetation than soil. - Adsorption of pesticides to plant surfaces. - Anchors soil during winter rains preventing soil, nutrient and pesticide runoff. - Allows pesticides to break down and be filtered onsite. Adds organic material to the soil. Accelerates the biodegradation of pesticides in soil. Can reduce plant parasitic nematodes by antagonism. Legume cover crops fix atmospheric nitrogen and release it to the orchard crop during the growing season. Improves water infiltration, soil aeration and soil texture. Improves soil fertility. Assists in weed control (seeded covers). Improves orchard access during wet weather. Cover crops provide nectar sources, pollen and prey for beneficial predators.
		Drawbacks	Difficult to manage if noxious weeds are present and requires mechanical or herbicide control in late winter or early spring if overgrown. Increased cover and feed for gophers, ground squirrels and mice (also higher populations from increased habitat and reduced predation). Increased humidity can potentially create conditions for fungal diseases. Potentially increased nematode populations with summer-grown cover crop. Higher water use with perennial cover crops. Sprinklers can be blocked by climbing vetches. Blooming cover crops can compete with tree crops for pollinator insects if not mowed. Increased danger of frost damage. A tall, dense cover crop can reduce nighttime temperatures by up to 5 or 6 degrees, increasing the potential for frost damage. However, orchards with closely mowed cover crops and moist soil may be only about 1 degree colder than bare soil. Alternate row cover cropping can reduce the difference even more. Mowing before frost reduces the risk of frost damage.

Cover Crop Management	**Cover and Green Manure Crop**	Plants are disked to incorporate organic material and improve soil fertility and tilth. Disking (or mowing) is generally done when plants are in full-bloom to post-bloom stage, depending on frost potential and soil moisture conditions.
	Mowed Cover Crop	Managed by mowing to maintain at least 60% ground cover where erosion is possible. Mowing to 3-4 inches prior to frost can reduce cold temperature damage potential. Mowing intervals can often allow adequate seed production for following season re-growth. Mowed cover crops reduce dust during harvest operations and improve water infiltration rates.
	Disked Cover Crop	Plants typically disked at full-bloom to post-bloom stage, depending on condition of the target crop, weather and soil moisture conditions. Maintain at least 60% ground cover where erosion is possible. Mowing to 3-4 inches prior to frost can reduce potential for cold temperature damage.
Vegetative Buffers	Areas or strips of land surrounding an orchard that are maintained in permanent vegetation. To effectively trap pesticides, buffers must slow water runoff and increase infiltration so that pesticides can be trapped and degraded in buffer soil and vegetation. Vegetative buffers are a tool to further improve water quality and provide additional benefits such as wildlife habitat and stream bank protection. For best success, they should be used in conjunction with other mitigation practices.	
	Benefits	Can be used to manage soil, water, nutrients and pesticides while minimizing environmental impacts. Effective in trapping eroded sediment, reducing runoff of pesticides that are adsorbed to soil particles. Note: some pesticides (e.g. OPs) are highly water soluble and don't adsorb to soil particles as readily as others (e.g. pyrethroids).
	Drawbacks	California-based research is limited on the potential for orchard filter strips and grassed waterways to reduce OP pesticide loading, although the practices have been shown to be effective in other regions of the U.S. Uncertainties of buffers include: appropriate dimensions for volume of water flow; appropriate plant species and plant density for the soil types and rainfall zones; considerations for various locations; slope and channel dimensions for grassed waterways; and dimensions for constructed wetlands. Can require growers to set aside productive acreage.
Vegetative Filter Strips	Areas of grass or other permanent vegetation used to reduce sediment, organics, nutrients, pesticides and other contaminants in runoff to maintain or improve water quality. Vegetative filter strips are located between crop fields and water bodies, i.e. grassed roadways. Plant material captures rainfall and retains nutrients. Roadways can be grassed or sod planted, as can sprayer mixing pads and wellheads. Depending upon the site, a full border around an orchard may not be necessary for mitigating impacts to surface water. Filter strips could be planted at low ends of fields or in other critical zones.	
	Benefits	Slows runoff allowing sediment to drop out of suspension. Traps sediment with adsorbed pesticide residues. Increases water infiltration into the soil profile. Catches some pesticide drift, preventing it from reaching the soil.

	Drawbacks	If water runoff is channeled, a grass strip may not effectively trap the adsorbed pesticides.
Vegetative Barriers	Narrow, permanent strips of stiff stemmed, erect, dense, perennial vegetation established in parallel rows and perpendicular to the dominant slope of the field.	
	Benefits	Effective in dispersing concentrated flow, thus increasing sediment trapping and water infiltration.
	Drawbacks	If water runoff is channeled, a vegetative barrier may not effectively trap the adsorbed pesticides.
Grassed Waterways	Natural or constructed channels planted in permanent vegetation and located in an area where runoff concentrates. Constructed waterways can be graded to carry surface water at a non-erosive velocity to a stable outlet. Waterways are most effective in trapping sediment and dissolved chemicals when designed to spread concentrated water flow evenly cross a vegetative filter adjacent to waterways.	
	Benefits	Helps slow the flow of water to a non-erosive level. Provides a means of trapping sediment, nutrients, and pesticides while preventing gully erosion. Provides habitat and cover for wildlife.
	Drawbacks	Overgrown channels causing waterway breaching and flooding can restrict storm flows. Due to the concentrated flow that normally occurs in waterways, sediment trapping and water infiltration can be minimal with large runoff events, but substantial with smaller events.
Riparian Buffers	Trees and shrubs planted adjacent to streams, lakes, ponds and wetlands. Forest buffers are frequently combined with an understory of perennial grass buffers.	
	Benefits	Helps lower water temperatures by shading the water body. Protects stream banks and slows out-of-bank flood flows. Deep tree roots may intercept nitrate entering streams in shallow subsurface flow and provide soil carbon for microbial energy. Microbes can denitrify nitrate and degrade pesticides. Woody vegetation provides food and cover for wildlife. Contributes energy sources to aquatic communities.
	Drawbacks	If water runoff is channeled, riparian buffers may not effectively trap pesticides.
Constructed Wetlands	Wetlands constructed at tile outlets or as part of riparian buffer systems for degrading pesticides and denitrifying nitrates.	
	Benefits	Provides confined area for breakdown of pesticides in water.
	Drawbacks	Land needed for constructed wetlands is not readily available in high production areas. Available land can be costly.
Hedgerows	Fences of shrubs or trees in, across, or around a field. Hedgerows can include an understory composed of perennial native grasses and forbs, a shrub midstory composed of California native species and occasionally a discontinuous overstory of valley and foothill trees.	

	Benefits	May reduce erosion by having perennial vegetation on a portion of the field. If runoff flows across the hedgerow in sheet flow, sediment can be trapped, reducing the amount of sediment and sediment-borne pesticides from entering surface waters. Can attract beneficial insects and provide competition against invasive weeds. Windbreaks and hedgerows can provide drift mitigation, potentially reducing off-site movement of pesticides. Because many of the native species used in hedgerows have deep roots that hold the soil and increase water permeability, there may be a reduction in water runoff and off site movement of sediment. This could reduce runoff of pesticides in the dissolved and sediment-borne phases of field runoff. However, no studies have quantitatively measured the reductions in OP pesticide runoff.
	Drawbacks	Certain plant species may attract pests that can attack the crop or neighboring crops. Careful consideration must be given to the species of vegetation selected and the types of insects that may be attracted. Plant species can provide habitat and attract endangered species. Safe Harbor Agreements are available to protect growers where a practice is implemented that could attract endangered species to their farms, a factor that should be evaluated and addressed before establishing hedgerows. Some species can grow 10-15 feet wide, so space must be allowed for equipment to pass.
Reducing or Eliminating the Herbicide-Sprayed Berm	Berm areas of orchards sprayed with herbicides represent a bare conduit for runoff of rainfall or irrigation water. By allowing vegetation to grow and reducing the berm width or seasonal spraying of the berm, runoff potential from an orchard could be reduced. Options - Reduce strip spray widths by 25%. - Apply herbicide in January/February after sprouted grass covers the berm. - Spray a 5-foot square block around trees to keep the trunk area clean but leave vegetation on the remainder of the row berm. - Stop spraying herbicides at the next-to-the-last tree in each row, leaving a vegetative barrier surrounding the orchard. - Eliminate use of pre-emergence herbicides.	
	Benefits	Cost Savings Reduction in runoff volume through increased soil infiltration. Decrease in soil erosion and movement of pesticides with soil borne runoff. Shorter pesticide persistence on vegetation than soil and better absorption on plant surfaces (faster degradation on plant matter). An orchard floor that is completely vegetated versus 25% bare soil has greater area for these mechanisms to function.
	Drawbacks	Vegetation on berms can be difficult to manage in orchards. Vegetation control can be difficult if excessive growth occurs before herbicide is applied.
In-Season Spray BMPs		
Insecticides & Herbicides		

Monitoring	Postbloom - Continue monitoring weather for conditions favorable to scab, fire blight, powdery mildew - Continue monitoring codling moth trap and check fruit - Continue to examine shoots and leaves for aphids, leafhopper nymphs, leafrolling caterpillars, tentiform leafminer and parasitism (April and May), and San Jose scale crawlers (May) - Monitor weeds for stink bugs and fruit for lygus bug damage Summer - Continue monitoring codling moth traps and check fruit - In mating disruption orchards, apply a second application of pheromone when first expires - Examine fruit for orange tortrix (July), pandemis (late June), obliquebanded leafroller (July-August), stink bug/lygus damage, and bitter pit (early varieties) - Examine leaves for mites, tentiform leafminer (June), leafhoppers Preharvest - Continue monitoring codling moth traps and check fruit - Examine fruit for bitter pit and lygus/stink bug damage - Examine leaves for mites and leafhoppers
Drift	The ability to detect products in streams and rivers at parts per trillion levels leaves little room for error. To prevent problems, equipment operators must take extra care when spraying near sensitive areas and bodies of water. Shutoff equipment when making row turns. Avoid spraying when wind is blowing toward waterways or other sensitive areas. Leave buffer zone to protect sensitive areas.
Managing Irrigation Runoff	Tailwater return systems can alleviate excess runoff preventing runoff from moving into surface waters. Use vegetative barriers (see dormant orchard field practices) to filter runoff prior to leaving site. Use of drip irrigation, especially buried drip has reduced or eliminated irrigation-induced runoff.
Cultural Controls	For Codling Moth: - Remove host trees in nearby abandoned orchards (apple, pear, and walnut) to destroy reservoirs of codling moth. - Remove fruit from nearby unsprayed apple, pear, and walnut trees, unpicked pollinizers and seedling trees in the orchard, as well as removing props, picking bins, and fruit piles from the orchard. - Prune tall, overly dense tree tops to improve spray coverage. - Hand thin to remove all infested fruit during each generation before worms leave fruit and pick up dropped fruit. Mites - Orchard management practices can reduce mite problems. Minimize dust by oiling orchard roads and maintaining a ground cover. Well-irrigated, vigorous trees are less troubled by mite infestations. - Grass cover crops and sprinkler irrigation help to minimize dust in orchards. Provide adequate irrigation to avoid water stress. Do not mow the cover crop too short or let it dry, or the mites may move up into the trees. - Choose selective pesticides when controlling other pests and try to avoid pyrethroids, organophosphates, and carbamates.

Stewardship BMPs	
Mixing / Loading/Cleanup	
Concrete or Asphalt Pad	Use concrete or asphalt pad that drains to a central sump
Proximity of mixing/loading area	Take precautions to insure that the minimum distance between any mixing/loading area and any ditches, canals or streams that feed into nearby rivers is at least 100 feet. Take precautions to insure that the minimum distance between any mixing/loading area and pump is at least 100 feet.
Equipment	Check equipment for cracked / broken hoses, valves, etc. Calibrate prior to each application. Use spray nozzles adjusted for crop canopy. Use nozzles with large droplet size to minimize drift.
Tank filling	Fill tank to 1/3 to ½ full prior to the addition of chemicals. Use air gap to prevent tank overfilling. Use backflow valve on the fill tube.
Personnel	Person(s) always present during mixing/loading operations. Person(s) trained to take corrective action when necessary.
Storage Areas	Have spill containment capability to protect from runoff into any nearby surface waters. Use impermeable surface (coated or sealed concrete) with curbs for floors.
Cleanup	Mix rinseate with water and reapply to field. Clean equipment on appropriate pad at least 300 feet from surface waters. Triple rinse empty containers and dispose of in landfill or recycling area.
Nutrient/Fertilizer Application BMPs	
Soil, Tissue and Water Testing	Base N fertilizer amount and timing on crop needs and production goals. Before applying N early in the growth cycle, assess the amount of nitrate already present by soil (or soil solution) sampling and analysis. Use plant tissue sampling for mid- and late season fertilizer decisions. Measure nitrate levels in the irrigation water and adjust N fertilizer rate accordingly.
Application Timing	When applying manure shortly before a crop is planted, determine the nutrient content of the manure and the amount of nitrate already present in the soil. Apply manure at a rate consistent with the crop nutrient requirements. Split applications of N fertilizer. No not apply excessive single amounts of fertilizer N during the rainy season. For fertilizer application during fall tillage, use only low N-containing materials such as N:P2O5:K2O equal to 1:3:3. Higher N materials may be appropriate if a crop is to be planted soon.

Fertilizer Placement	Place N fertilizer materials where maximum plant uptake will occur. Incorporate N fertilizer into the crop bed by either placing fertilizer on or near the seed row and watering it in, knifing fertilizer into the bed or broadcasting fertilizer then listing it up into the bed. Incorporate manures and other organic amendments into soil with consideration of the timing of conversion of manure N to other forms.	
Irrigation	Adopt surge irrigation. Improve irrigation uniformity by turning irrigation water on and off as it flows down the furrow. If fields are more than 1000 feet long, consider cutting the furrow run length in half with a corresponding decrease in set time. Use high flow rates initially to get water down the field and then cut back to finish off the irrigation. Avoid doing the opposite. Use practices that increase uniformity among furrows (e.g. torpedoes, extra tractor trips, etc.) Collect surface water runoff for recirculation or reuse in other fields.	
Application Practices	Clean-up fertilizer spills promptly. Shut off fertilizer applicators during turns and use check valves when possible. Maintain proper calibration of fertilizer application equipment. Whenever injecting fertilizer into irrigation water, ensure backflow does not occur. Rinse water from fertilizer tanks should be evenly spread throughout a field. Fertilizer tanks and equipment should be cleaned by rinsing in the field or at a properly designed wash facility. Rinse water and/or sludge should be evenly spread across a field using good agronomic practices. When equipment is parked, use care to prevent material from leaking into storage area. If equipment is known to be in disrepair, completely remove fertilizer material before parking equipment. When transferring fertilizer into on-farm storage or into a fertilizer applicator, take care not to allow materials to accumulate on the soil. Good housekeeping practices should be implemented to prevent contamination of groundwater and/or surface water.	
Cover Crops	If conditions permit, grow a cover crop to use excess nitrogen and prevent leaching rather than leaving fields fallow during the rainy season.	
Sediment Control BMPs		
Water and Sediment Control Basins	Constructed earth embankments or a combination ridge and channel. Constructed across the slope and minor watercourses to form a sediment trap and water detention basin.	
	Benefits	Trap sediment and pesticides adsorbed to soil particles. Reduce and manage onsite and downstream runoff. Divert the flow of dissolved substances such as nutrients and pesticides. Improve the farmability of sloping land, reduce water course and gully erosion. Improve downstream water quality.
	Drawbacks	Basins are not viable for many orchard areas in California, primarily because considerable land acreage would be required to manage the volumes of water typically produced in rainfall events, especially in the Sacramento Valley.

PAM Applications	PAM is a polymer compound injected or fed into irrigation water at the head of a field supply ditch or discharge point. Applications rates range from 5-8 pounds per acre with the material typically metered into the head ditch with a gandy-type applicator	
	Benefits	In newly formed furrows, soil does not move down the row or erode when irrigation water is treated with PAM. Suspended soil particles drop out of irrigation water containing PAM. After an irrigation containing PAM, furrow erosion and transport of sediment is greatly reduced in subsequent irrigations. Erosion reductions of 95% have been documented in numerous field trials and commercial applications in the San Joaquin Valley.
	Drawbacks	Additional cost
Tailwater Return Systems	**Benefits**	Use of tailwater can offer substantial savings in irrigation power consumption if the water supply is groundwater. A tailwater recovery system increases yields because of higher irrigation efficiencies. A tailwater recovery system will not save all the tailwater, but it can increase irrigation efficiency by 25 to 30 percent.
	Drawbacks	The loss of the area required for a reuse pit and periodic maintenance of the pump, storage and return facilities.
Compaction / Wheel Rutting	Wheel ruts formed by equipment passing through wet fields can create channels for water and sediment to runoff from orchards. Where possible, minimize creation of wheel ruts with dormant orchard sprayers, brush shredders or other equipment when orchard floor is saturated.	
Drainage System Management	Filtering runoff water through vegetation allowed to grow in drainage ditches may help mitigate offsite movement of sediment as well as pesticides dissolved in storm runoff.	
Avoiding Channelization of Streams and Creeks	Allowing streams to naturally flow and meander can increase runoff retention and infiltration. A modified or channeled stream could also be restored to a more natural state by re-establishment of the riparian vegetation, which also provides stream bank protection.	
Berms at Low Ends of Fields (sandy soils, low slope)	Raised berms at low ends of fields can trap sediment and adsorbed pesticides reducing runoff of dissolved substances in fields with low slopes and sandy soil types. Berms hold back water, increasing runoff retention and allowing infiltration.	
Planting 90 degrees to Grade	Planting orchards and performing tractor work 90 degrees to the grade to reduce erosion and provide for greater water penetration and retention. Practice is very site-specific and would not be easily adaptable to many existing orchards, particularly those that are flood irrigated.	
Aeration	Use of specialized tillage equipment to break crusts and aerate orchard soils with the intent of increasing water penetration and retention, thus reducing runoff. Aeration improves the soil profile with minimal disruption to the orchard floor. Aeration may reduce OP pesticide runoff although no studies have been conducted.	

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<tr><td rowspan="1">Ripped Resident Vegetation</td><td colspan="2">In orchards with permanent or semi-permanent sod, vegetation is ripped at various lengths and/or depths.
Ripping significantly increases soil water due to increased infiltration and porosity. Heavy rains after fall ripping can leave orchards impassable to heavy equipment such as orchard sprayers. In recent research, ripped resident vegetation performed the best for infiltration and reduced diazinon transport, followed by non-ripped resident vegetation and bare ground being the least effective.</td></tr>
<tr><td rowspan="3">Improving soil texture (tilth)</td><td colspan="2">Practices such as tillage, gypsum applications or actions of earthworms have potential to increase water penetration and reduce runoff in compacted soils or where an impermeable soil layer exists. However, no studies have been conducted to show efficacy in reducing OP pesticide runoff with these approaches.</td></tr>
<tr><td>Benefits</td><td>Increased water penetration resulting in less runoff and increased recharging of the soil profile.
Less water runoff means less potential for pesticides to be transported off-site.</td></tr>
<tr><td>Drawbacks</td><td>Tillage can increase erosion under some conditions and necessitate additional orchard floor finishing work (scraping).
Results vary with soil type and, under some conditions, compaction could increase.
Improved soil permeability may increase movement of nitrate and other chemicals into groundwater. The balance of benefits versus disadvantages is not clear at this time and more research is needed.</td></tr>
</table>

Reference:

Integrated Pest Management for Apples and Pears 2nd Edition: University of California, Division of Agriculture and Natural Resources. 1999. 232pp.

http://ipm.ucdavis.edu/PMG/selectnewpest.apples.html

Orchard Practices for Protecting Surface Water: Coalition for Urban/Rural Environmental Stewardship (http://www.curesworks.org)

Mixing and Loading Crop Sprayers, Tips and Techniques, Protecting Water Quality: Coalition for Urban/Rural Environmental Stewardship (http://www.curesworks.org)

Field and Row Crop Sprayers, Tips and Techniques, Protecting Water Quality: Coalition for Urban/Rural Environmental Stewardship (http://www.curesworks.org)

Crop: Cherries	
Compilation of Best Management Practices to Protect Surface Water from Farm Runoff	
Pesticide Application BMPs	
Dormant Season Sprays	
Monitoring	Improved monitoring can lead to reduced sprays through “spray when necessary” rather than “calendar” timing. During the dormant season, check prunings from tree tops to see if scale infestations are developing. Look for dead leaves clinging to branches, a sign of heavy scale infestations. Base treatment decisions on monitoring of the field.
Dormant Diazinon and Oil Spray	Diazinon combined with dormant oil during the dormant season. Diazinon applications are frequently alternated with non-OP pesticides to prevent resistance from developing to either diazinon or non-OP pesticides. Information is being developed on earlier timing of winter OP applications when less rainfall is likely or when the rainfall is more likely to be absorbed into the soil rather than runoff. Due to the damage potential of San Jose scale, annual dormant sprays are recommended in most areas followed by regular monitoring to see if populations are increasing and to assess the presence of biological control. Dormant oil without organophosphates is effective against the white cap and black cap stages but will not control mature scales. Good spray coverage and sufficiently high application rates are essential for effective control; do not reduce dormant oil rates if scale is present. Control moderate to heavy populations of San Jose scale by applying an organophosphate insecticide with the oil spray. Reduced rates: additional data is needed to demonstrate effects at varying pest densities.
No Dormant Treatment or Dormant Oil Only Treatment	Dormant insecticide spray is not applied or an oil only treatment is made. Skipping dormant insecticide sprays has been successful when pest pressure is low or non-existent.
Alternate Year Dormant OP Pesticide With Yearly Oil Spray	Use dormant OP every other year but use dormant oil on an annual basis. In years with no dormant OP used the following may be necessary: - Additional in-season treatments. - Additional in-season treatments for mites are possible following in-season applications of carbaryl, esfenvalerate and permethrin.

Dormant Spray (Non-OP Pesticides) and Oil	Pyrethroids (permethrin and esfenvalerate) and carbamates (carbaryl) in the delayed-dormant or dormant season. Residues of the pyrethroid insecticides permethrin and esfenvalerate persist on bark and may impact naturally occurring predator mites for extended periods of time after dormant season and in-season applications. Mite outbreaks caused by use of pyrethroids may require additional miticide treatments over and above those normally applied. In general, insects become resistant to pyrethroids more rapidly than other classes of pesticides. Some registered products are not widely used in the dormant season because of possible effects on non-target organisms or because of label restrictions. For example, carbaryl cannot be used in orchards where honeybees are present and endosulfan use is restricted near water or wetlands. Non-OP pesticides can affect non-target organisms in water and the potential for offsite movement from runoff has not been well studied. If a non-OP pesticide is applied as a dormant spray, precautions such as on-site practices (following sections) should be taken to prevent movement into surface waters. Laboratory exposures indicate that fish and invertebrates are particularly sensitive to pyrethroids. Pyrethroid persistence may mean that they will be transported off site. If so, they may be bioavailable to fish in water or to invertebrates in sediment. Sediment toxicity may result after pyrethroids are transported into water bodies.
Delayed Dormant Treatment	Delayed dormancy is the period from the resumption of growth, indicated by bud swell until green tip. Control heavy populations of San Jose scale by applying an organophosphate insecticide with the oil spray during the delayed dormant period.
Pheromone Mating Disruption	Mating disruption relies on releasing pheromones through dispensers distributed throughout an orchard or applied as a spray. Pheromone mating disruption cannot be considered a stand-alone system. It is selective for the target pest so monitoring for other orchard pests as well as the target pest is necessary.
Dormant Season Spray BMPs	

Restrict dormant spray applications (except oil alone) to ground applications only. Do not apply within 100 feet upslope of any sensitive aquatic site that may drain into a river or tributary unless runoff is contain or diverted from the sensitive aquatic site. Waters that are contained or diverted must be held for 72 hours before they can be released into a sensitive aquatic site. Maintain a vegetative buffer strip a minimum of 10 feet wide from the edge of the field to sensitive aquatic sites. Do not apply dormant sprays (except oil alone) when soil moisture is at field capacity and a storm is predicted in the next 48 hours. Do not apply dormant sprays (except oil alone) when surface runoff to sensitive aquatic sites from a rain event could occur within 48 hours after the application. Make dormant applications only when insect-scouting information indicates pest populations have reached damaging levels. (See University of California Integrated Pest Management Guidelines for cherries.) Apply only when wind speed is 3-10 mph at the application site as measured by an anemometer outside of the orchard on the upwind side. When air currents are moving (>3 mph) toward sensitive aquatic sites, commence applications on side nearest the site and proceed spraying away from the water body. Spray last three rows upwind of bodies of water using nozzles on one side only, with spray directed away from sensitive aquatic sites. Reduce the maximum rate of application and the number of applications. Alternate the dormant use of organophosphorous and pyrethroid insecticides with other environmentally reduced risk pesticides or make application in season according to University of California Integrated Pest Management recommendations.	
Dormant Orchard Field Practice BMPs	
Orchard Floor Vegetation During Dormant Season	Seeded or resident vegetation growing on orchard floors that is later mowed or disked. Resident Vegetation - existing, unplanted mixture of annual or perennial weeds, crop species and/or native grasses and forbs which has adapted to management methods used in the orchard. Seeded vegetation - cover crops that include many types of cultivated species including legumes (bell beans, peas, clover, medics and vetches) and grasses such as cereal grains, turf grasses and sudan grass.

	Resident or Seeded Vegetation (continued)	**Benefits**	Orchard floor vegetation can reduce dormant spray pesticide runoff to surface waters in several ways: - Can be easily encouraged to grow in the fall or early winter by a post harvest irrigation or early rains and requires little to no management to establish. - Reduction in runoff volume through increased water infiltration. - Reduction in sheet erosion caused by rainfall impact on bare ground. - Decrease in pesticide mass carried by sediment. - Shorter pesticide persistence (faster breakdown) on vegetation than soil. - Adsorption of pesticides to plant surfaces. - Anchors soil during winter rains preventing soil, nutrient and pesticide runoff. - Allows pesticides to break down and be filtered onsite. Adds organic material to the soil. Accelerates the biodegradation of pesticides in soil. Can reduce plant parasitic nematodes by antagonism. Legume cover crops fix atmospheric nitrogen and release it to the orchard crop during the growing season. Improves water infiltration, soil aeration and soil texture. Improves soil fertility. Assists in weed control (seeded covers). Improves orchard access during wet weather. Cover crops provide nectar sources, pollen and prey for beneficial predators.
		Drawbacks	Difficult to manage if noxious weeds are present and requires mechanical or herbicide control in late winter or early spring if overgrown. Increased cover and feed for gophers, ground squirrels and mice (also higher populations from increased habitat and reduced predation). Increased humidity can potentially create conditions for fungal diseases. Potentially increased nematode populations with summer-grown cover crop. Higher water use with perennial cover crops. Sprinklers can be blocked by climbing vetches. Blooming cover crops can compete with tree crops for pollinator insects if not mowed. Increased danger of frost damage. A tall, dense cover crop can reduce nighttime temperatures by up to 5 or 6 degrees, increasing the potential for frost damage. However, orchards with closely mowed cover crops and moist soil may be only about 1 degree colder than bare soil. Alternate row cover cropping can reduce the difference even more. Mowing before frost reduces the risk of frost damage.

Cover Crop Management	**Cover and Green Manure Crop**	Plants are disked to incorporate organic material and improve soil fertility and tilth. Disking (or mowing) is generally done when plants are in full-bloom to post-bloom stage, depending on frost potential and soil moisture conditions.
	Mowed Cover Crop	Managed by mowing to maintain at least 60% ground cover where erosion is possible. Mowing to 3-4 inches prior to frost can reduce cold temperature damage potential. Mowing intervals can often allow adequate seed production for following season re-growth. Mowed cover crops reduce dust during harvest operations and improve water infiltration rates.
	Disked Cover Crop	Plants typically disked at full-bloom to post-bloom stage, depending on condition of the target crop, weather and soil moisture conditions. Maintain at least 60% ground cover where erosion is possible. Mowing to 3-4 inches prior to frost can reduce potential for cold temperature damage.
Vegetative Buffers	Areas or strips of land surrounding an orchard that are maintained in permanent vegetation. To effectively trap pesticides, buffers must slow water runoff and increase infiltration so that pesticides can be trapped and degraded in buffer soil and vegetation. Vegetative buffers are a tool to further improve water quality and provide additional benefits such as wildlife habitat and stream bank protection. For best success, they should be used in conjunction with other mitigation practices.	
	Benefits	Can be used to manage soil, water, nutrients and pesticides while minimizing environmental impacts. Effective in trapping eroded sediment, reducing runoff of pesticides that are adsorbed to soil particles. Note: some pesticides (e.g. OPs) are highly water soluble and don't adsorb to soil particles as readily as others (e.g. pyrethroids).
	Drawbacks	California-based research is limited on the potential for orchard filter strips and grassed waterways to reduce OP pesticide loading, although the practices have been shown to be effective in other regions of the U.S. Uncertainties of buffers include: appropriate dimensions for volume of water flow; appropriate plant species and plant density for the soil types and rainfall zones; considerations for various locations; slope and channel dimensions for grassed waterways; and dimensions for constructed wetlands. Can require growers to set aside productive acreage.
Vegetative Filter Strips	Areas of grass or other permanent vegetation used to reduce sediment, organics, nutrients, pesticides and other contaminants in runoff to maintain or improve water quality. Vegetative filter strips are located between crop fields and water bodies, i.e. grassed roadways. Plant material captures rainfall and retains nutrients. Roadways can be grassed or sod planted, as can sprayer mixing pads and wellheads. Depending upon the site, a full border around an orchard may not be necessary for mitigating impacts to surface water. Filter strips could be planted at low ends of fields or in other critical zones.	
	Benefits	Slows runoff allowing sediment to drop out of suspension. Traps sediment with adsorbed pesticide residues. Increases water infiltration into the soil profile. Catches some pesticide drift, preventing it from reaching the soil.

	Drawbacks	If water runoff is channeled, a grass strip may not effectively trap the adsorbed pesticides.
Vegetative Barriers	Narrow, permanent strips of stiff stemmed, erect, dense, perennial vegetation established in parallel rows and perpendicular to the dominant slope of the field.	
	Benefits	Effective in dispersing concentrated flow, thus increasing sediment trapping and water infiltration.
	Drawbacks	If water runoff is channeled, a vegetative barrier may not effectively trap the adsorbed pesticides.
Grassed Waterways	Natural or constructed channels planted in permanent vegetation and located in an area where runoff concentrates. Constructed waterways can be graded to carry surface water at a non-erosive velocity to a stable outlet. Waterways are most effective in trapping sediment and dissolved chemicals when designed to spread concentrated water flow evenly cross a vegetative filter adjacent to waterways.	
	Benefits	Helps slow the flow of water to a non-erosive level. Provides a means of trapping sediment, nutrients, and pesticides while preventing gully erosion. Provides habitat and cover for wildlife.
	Drawbacks	Overgrown channels causing waterway breaching and flooding can restrict storm flows. Due to the concentrated flow that normally occurs in waterways, sediment trapping and water infiltration can be minimal with large runoff events, but substantial with smaller events.
Riparian Buffers	Trees and shrubs planted adjacent to streams, lakes, ponds and wetlands. Forest buffers are frequently combined with an understory of perennial grass buffers.	
	Benefits	Helps lower water temperatures by shading the water body. Protects stream banks and slows out-of-bank flood flows. Deep tree roots may intercept nitrate entering streams in shallow subsurface flow and provide soil carbon for microbial energy. Microbes can denitrify nitrate and degrade pesticides. Woody vegetation provides food and cover for wildlife. Contributes energy sources to aquatic communities.
	Drawbacks	If water runoff is channeled, riparian buffers may not effectively trap pesticides.
Constructed Wetlands	Wetlands constructed at tile outlets or as part of riparian buffer systems for degrading pesticides and denitrifying nitrates.	
	Benefits	Provides confined area for breakdown of pesticides in water.
	Drawbacks	Land needed for constructed wetlands is not readily available in high production areas. Available land can be costly.
Hedgerows	Fences of shrubs or trees in, across, or around a field. Hedgerows can include an understory composed of perennial native grasses and forbs, a shrub midstory composed of California native species and occasionally a discontinuous overstory of valley and foothill trees.	

<table>
<tr><td rowspan="2"></td><td>Benefits</td><td>May reduce erosion by having perennial vegetation on a portion of the field.
If runoff flows across the hedgerow in sheet flow, sediment can be trapped, reducing the amount of sediment and sediment-borne pesticides from entering surface waters.
Can attract beneficial insects and provide competition against invasive weeds.
Windbreaks and hedgerows can provide drift mitigation, potentially reducing off-site movement of pesticides.
Because many of the native species used in hedgerows have deep roots that hold the soil and increase water permeability, there may be a reduction in water runoff and off site movement of sediment. This could reduce runoff of pesticides in the dissolved and sediment-borne phases of field runoff. However, no studies have quantitatively measured the reductions in OP pesticide runoff.</td></tr>
<tr><td>Drawbacks</td><td>Certain plant species may attract pests that can attack the crop or neighboring crops. Careful consideration must be given to the species of vegetation selected and the types of insects that may be attracted.
Plant species can provide habitat and attract endangered species. Safe Harbor Agreements are available to protect growers where a practice is implemented that could attract endangered species to their farms, a factor that should be evaluated and addressed before establishing hedgerows.
Some species can grow 10-15 feet wide, so space must be allowed for equipment to pass.</td></tr>
<tr><td rowspan="3">Reducing or Eliminating the Herbicide-Sprayed Berm</td><td colspan="2">Berm areas of orchards sprayed with herbicides represent a bare conduit for runoff of rainfall or irrigation water.
By allowing vegetation to grow and reducing the berm width or seasonal spraying of the berm, runoff potential from an orchard could be reduced.
Options
- Reduce strip spray widths by 25%.
- Apply herbicide in January/February after sprouted grass covers the berm.
- Spray a 5-foot square block around trees to keep the trunk area clean but leave vegetation on the remainder of the row berm.
- Stop spraying herbicides at the next-to-the-last tree in each row, leaving a vegetative barrier surrounding the orchard.
- Eliminate use of pre-emergence herbicides.</td></tr>
<tr><td>Benefits</td><td>Cost Savings
Reduction in runoff volume through increased soil infiltration.
Decrease in soil erosion and movement of pesticides with soil borne runoff.
Shorter pesticide persistence on vegetation than soil and better absorption on plant surfaces (faster degradation on plant matter). An orchard floor that is completely vegetated versus 25% bare soil has greater area for these mechanisms to function.</td></tr>
<tr><td>Drawbacks</td><td>Vegetation on berms can be difficult to manage in orchards.
Vegetation control can be difficult if excessive growth occurs before herbicide is applied.</td></tr>
<tr><td colspan="3">In-Season Spray BMPs</td></tr>
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</table>

Monitoring	Mites - Monitor for mites beginning in March.
Drift	The ability to detect products in streams and rivers at parts per trillion levels leaves little room for error. To prevent problems, equipment operators must take extra care when spraying near sensitive areas and bodies of water. Shutoff equipment when making row turns. Avoid spraying when wind is blowing toward waterways or other sensitive areas. Leave buffer zone to protect sensitive areas.
Managing Irrigation Runoff	Tailwater return systems can alleviate excess runoff preventing runoff from moving into surface waters. Use vegetative barriers (see dormant orchard field practices) to filter runoff prior to leaving site. Use of drip irrigation, especially buried drip has reduced or eliminated irrigation-induced runoff.
Cultural Controls	Mites - Reduce dusty conditions in orchards by oiling or watering roadways and maintaining a groundcover. - Prevent water stress, as this condition results in higher mite densities and intensified damage. - Choose selective pesticides when controlling other pests and try to avoid pyrethroids, organophosphates, and carbamates.
Stewardship BMPs	
Mixing / Loading/Cleanup	
Concrete or Asphalt Pad	Use concrete or asphalt pad that drains to a central sump
Proximity of mixing/loading area	Take precautions to insure that the minimum distance between any mixing/loading area and any ditches, canals or streams that feed into nearby rivers is at least 100 feet. Take precautions to insure that the minimum distance between any mixing/loading area and pump is at least 100 feet.
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Practice is very site-specific and would not be easily adaptable to many existing orchards, particularly those that are flood irrigated.</td></tr>
<tr><td>Aeration</td><td colspan="2">Use of specialized tillage equipment to break crusts and aerate orchard soils with the intent of increasing water penetration and retention, thus reducing runoff.
Aeration improves the soil profile with minimal disruption to the orchard floor. Aeration may reduce OP pesticide runoff although no studies have been conducted.</td></tr>
<tr><td>Ripped Resident Vegetation</td><td colspan="2">In orchards with permanent or semi-permanent sod, vegetation is ripped at various lengths and/or depths.
Ripping significantly increases soil water due to increased infiltration and porosity. Heavy rains after fall ripping can leave orchards impassable to heavy equipment such as orchard sprayers. In recent research, ripped resident vegetation performed the best for infiltration and reduced diazinon transport, followed by non-ripped resident vegetation and bare ground being the least effective.</td></tr>
<tr><td rowspan="3">Improving soil texture (tilth)</td><td colspan="2">Practices such as tillage, gypsum applications or actions of earthworms have potential to increase water penetration and reduce runoff in compacted soils or where an impermeable soil layer exists. However, no studies have been conducted to show efficacy in reducing OP pesticide runoff with these approaches.</td></tr>
<tr><td>Benefits</td><td>Increased water penetration resulting in less runoff and increased recharging of the soil profile.
Less water runoff means less potential for pesticides to be transported off-site.</td></tr>
<tr><td>Drawbacks</td><td>Tillage can increase erosion under some conditions and necessitate additional orchard floor finishing work (scraping).
Results vary with soil type and, under some conditions, compaction could increase.
Improved soil permeability may increase movement of nitrate and other chemicals into groundwater. The balance of benefits versus disadvantages is not clear at this time and more research is needed.</td></tr>
</table>

Reference:

Integrated Pest Management for Stone Fruits: University of California Statewide IPM Project. 1999. 264pp.

http://ipm.ucdavis.edu/PMG/selectnewpest.cherries.html

Orchard Practices for Protecting Surface Water: Coalition for Urban/Rural Environmental Stewardship (http://www.curesworks.org)

Mixing and Loading Crop Sprayers, Tips and Techniques, Protecting Water Quality: Coalition for Urban/Rural Environmental Stewardship (http://www.curesworks.org)

Field and Row Crop Sprayers, Tips and Techniques, Protecting Water Quality: Coalition for Urban/Rural Environmental Stewardship (http://www.curesworks.org)

Crop: Corn		
Compilation of Best Management Practices to Protect Surface Water from Farm Runoff		
Pesticide Application BMPs		
In-Season Sprays		
Improved Monitoring	Monitoring is key, especially for sweet corn when trying to control corn earworm. Improved monitoring can lead to reduced sprays through "spray when necessary" rather than "calendar" timing. Base treatment decisions on monitoring of the field and type of corn (field or sweet).	
Organophosphates	Benefits	Excellent control of targeted insects.
	Drawbacks	Easily transported in water. Moderate duration of impact to beneficials, although less than pyrethroids.
Pyrethroids	**Benefits**	Excellent control of targeted insects. Not easily transported in water since they attach easily to soil particles
	Drawbacks	Resistance occurs quicker in pyrethroids than other classes of chemicals. Long duration of impact to beneficials, leading to secondary pest outbreaks. Highly toxic to fish in solution. Can be transported off-site with sediment during rainfall or irrigation events. Highly toxic to bees
Alternate Materials	Please consult your PCA for information concerning alternate materials.	
In-Season Spray BMPs		
Insecticides & Herbicides		

<table>
<tr><td>Drift</td><td colspan="3">The ability to detect products in streams and rivers at parts per trillion levels leaves little room for error.
To prevent problems, equipment operators must take extra care when spraying near sensitive areas and bodies of water.
Shutoff equipment near windrow ends.
Avoid applying when wind is blowing toward waterways or other sensitive areas.
Leave buffer zone to protect sensitive areas.
Use of larger droplet sizes.
Use of drift retardant chemicals in the spray mix. Although these are effective in reducing the number of drift-prone droplets, in most cases it is more effective to select the proper size and type of nozzles and operate sprayers at low pressure to produce the desired drop size, rather than attempt to increase droplet size with drift retardant chemicals.</td></tr>
<tr><td colspan="4">Corn Field Practice BMPs</td></tr>
<tr><td>Cultural Practices</td><td colspan="3">Weeds can harbor destructive insect pests such as thrips, which can vector Fusarium ear rot, and armyworms, which can defoliate corn. An integrated weed management program utilizes a combination of cultural, mechanical, and chemical methods for consistent, effective weed control. A vigorous, competitive crop produced through proper seedbed preparation, variety selection, seeding rates, fertilization, irrigation, cultivation, pest control, and crop rotation is the best defense against weed infestations and competition. In California a well-managed corn crop is extremely competitive with most weeds. Good cultural practices combined with timely cultivations often control weeds sufficiently. Genetically engineered (transgenic) corn varieties are being grown in California and provide additional options for weed control. Insertion of genes that transfer tolerance for glyphosate (Roundup) expands control of annual and perennial grasses and broadleaf weeds.
In sweet corn, very early plantings require fewer treatments than late-season corn because earworm population densities increase as the season progresses.
Reduce spider mite problems by keeping fields, field margins, and irrigation ditches clean of weed hosts. Spider mite populations may increase more rapidly in areas where dust deposits are heavy on corn leaves. Thus, reducing dust may reduce the spider mite problem. Spider mite populations may be held at very low levels by a number of predatory insects and mites, particularly early in the season.
Minimizing early season insecticide applications, which may reduce populations of beneficials, will reduce spider mite outbreaks.</td></tr>
<tr><td rowspan="4">Irrigation Runoff Management</td><td rowspan="2">Catchment basins</td><td>Benefits</td><td>Catchment basins with tailwater return systems can alleviate excess runoff preventing runoff from moving into surface waters.
Water savings</td></tr>
<tr><td>Drawbacks</td><td>Unlined catchment basins can contribute to downward movement of pesticides towards groundwater, so design is very crucial.</td></tr>
<tr><td>Improved soil monitoring</td><td colspan="2">Timing of irrigations is important so that moisture levels are not too high when irrigations occur, allowing for increased infiltration.</td></tr>
<tr><td>PAM Applications</td><td colspan="2">PAM is a polymer compound injected or fed into irrigation water at the head of a field supply ditch or discharge point.
Applications rates range from 5-8 pounds per acre with the material typically metered into the head ditch with a gandy-type applicator</td></tr>
</table>

		Benefits	In newly formed furrows, soil does not move down the row or erode when irrigation water is treated with PAM. Suspended soil particles drop out of irrigation water containing PAM. After an irrigation containing PAM, furrow erosion and transport of sediment is greatly reduced in subsequent irrigations. Erosion reductions of 95% have been documented in numerous field trials and commercial applications in the San Joaquin Valley.
		Drawbacks	Additional cost. Is not effective in preventing solubilized pesticides from moving off-site.
	Sprinklers	Amount of water can be controlled and therefore runoff is more easily controlled.	
Vegetative Buffers	Areas or strips of land surrounding a field that are maintained in permanent vegetation. To effectively trap pesticides, buffers must slow water runoff and increase infiltration so that pesticides can be trapped and degraded in buffer soil and vegetation. Vegetative buffers are a tool to further improve water quality and provide additional benefits such as wildlife habitat and stream bank protection. For best success, they should be used in conjunction with other mitigation practices.		
	Benefits	Can be used to manage soil, water, nutrients and pesticides while minimizing environmental impacts. Effective in trapping eroded sediment, reducing runoff of pesticides that are adsorbed to soil particles. Note: some pesticides (e.g. OPs) are highly water soluble and don't adsorb to soil particles as readily as others (e.g. pyrethroids).	
	Drawbacks	California-based research is limited on the potential for filter strips and grassed waterways to reduce OP pesticide loading, although the practices have been shown to be effective in other regions of the U.S. Uncertainties of buffers include: appropriate dimensions for volume of water flow; appropriate plant species and plant density for the soil types and rainfall zones; considerations for various locations; slope and channel dimensions for grassed waterways; and dimensions for constructed wetlands. Can require growers to set aside productive acreage.	
Vegetative Filter Strips	Areas of grass or other permanent vegetation used to reduce sediment, organics, nutrients, pesticides and other contaminants in runoff to maintain or improve water quality. Vegetative filter strips are located between crop fields and water bodies, i.e. grassed roadways. Plant material captures rainfall and retains nutrients. Roadways can be grassed or sod planted, as can sprayer mixing pads and wellheads. Depending upon the site, a full border around a field may not be necessary for mitigating impacts to surface water. Filter strips could be planted at tail ends of fields or in other critical zones.		
	Benefits	Slows runoff allowing sediment to drop out of suspension. Traps sediment with adsorbed pesticide residues. Increases water infiltration into the soil profile. Catches some pesticide drift, preventing it from reaching the soil.	
	Drawbacks	If water runoff is channeled, a grass strip may not effectively trap the adsorbed pesticides.	

Grassed Waterways	Natural or constructed channels planted in permanent vegetation and located in an area where runoff concentrates. Constructed waterways can be graded to carry surface water at a non-erosive velocity to a stable outlet. Waterways are most effective in trapping sediment and dissolved chemicals when designed to spread concentrated water flow evenly cross a vegetative filter adjacent to waterways.	
	Benefits	Helps slow the flow of water to a non-erosive level. Provides a means of trapping sediment, nutrients, and pesticides while preventing gully erosion. Provides habitat and cover for wildlife.
	Drawbacks	Overgrown channels causing waterway breaching and flooding can restrict storm flows. Due to the concentrated flow that normally occurs in waterways, sediment trapping and water infiltration can be minimal with large runoff events, but substantial with smaller events.
Filter Ditches	Areas filled with activated charcoal, peat, or other filtering agents at locations where water leaves the ranch. These would be replaced periodically and would filter pesticides before the soil solution reaches surface water.	
	Benefits	Further research is needed in California but other areas of the US have shown effective reduction of pesticide residue.
	Drawbacks	High cost due to materials and increased maintenance needed.
Riparian Buffers	Trees and shrubs planted adjacent to streams, lakes, ponds and wetlands. Forest buffers are frequently combined with an understory of perennial grass buffers.	
	Benefits	Helps lower water temperatures by shading the water body. Protects stream banks and slows out-of-bank flood flows. Deep tree roots may intercept nitrate entering streams in shallow subsurface flow and provide soil carbon for microbial energy. Microbes can denitrify nitrate and degrade pesticides. Woody vegetation provides food and cover for wildlife. Contributes energy sources to aquatic communities.
	Drawbacks	If water runoff is channeled, riparian buffers may not effectively trap pesticides.
Constructed Wetlands	Wetlands constructed at tile outlets or as part of riparian buffer systems for degrading pesticides and denitrifying nitrates.	
	Benefits	Provides confined area for breakdown of pesticides in water.
	Drawbacks	Land needed for constructed wetlands is not readily available in high production areas. Available land can be costly.
Hedgerows	Fences of shrubs or trees in, across, or around a field. Hedgerows can include an understory composed of perennial native grasses and forbs, a shrub midstory composed of California native species and occasionally a discontinuous overstory of valley and foothill trees.	

	Benefits	May reduce erosion by having perennial vegetation on a portion of the field. If runoff flows across the hedgerow in sheet flow, sediment can be trapped, reducing the amount of sediment and sediment-borne pesticides from entering surface waters. Can attract beneficial insects and provide competition against invasive weeds. Windbreaks and hedgerows can provide drift mitigation, potentially reducing off-site movement of pesticides. Because many of the native species used in hedgerows have deep roots that hold the soil and increase water permeability, there may be a reduction in water runoff and off site movement of sediment. This could reduce runoff of pesticides in the dissolved and sediment-borne phases of field runoff. However, no studies have quantitatively measured the reductions in OP pesticide runoff.
	Drawbacks	Certain plant species may attract pests that can attack the crop or neighboring crops. Careful consideration must be given to the species of vegetation selected and the types of insects that may be attracted. Plant species can provide habitat and attract endangered species. Safe Harbor Agreements are available to protect growers where a practice is implemented that could attract endangered species to their farms, a factor that should be evaluated and addressed before establishing hedgerows. Some species can grow 10-15 feet wide, so space must be allowed for equipment to pass.
Stewardship BMPs		
Mixing / Loading/Cleanup		
Concrete or Asphalt Pad	Use concrete or asphalt pad that drains to a central sump	
Proximity of mixing/loading area	Take precautions to insure that the minimum distance between any mixing/loading area and any ditches, canals or streams that feed into nearby rivers is at least 100 feet. Take precautions to insure that the minimum distance between any mixing/loading area and pump is at least 100 feet.	
Equipment	Check equipment for cracked / broken hoses, valves, etc. Calibrate prior to each application. Use spray nozzles with large droplet size to minimize drift.	
Tank filling	Fill tank to 1/3 to ½ full prior to the addition of chemicals. Use air gap to prevent tank overfilling. Use backflow valve on the fill tube.	
Personnel	Person(s) always present during mixing/loading operations. Person(s) trained to take corrective action when necessary.	
Storage Areas	Have spill containment capability to protect from runoff into any nearby surface waters. Use impermeable surface (coated or sealed concrete) with curbs for floors.	
Cleanup	Mix rinseate with water and reapply to field. Clean equipment on appropriate pad at least 300 feet from surface waters. Triple rinse empty containers and dispose of in landfill or recycling area.	

Nutrient/Fertilizer Application BMPs	
Soil, Tissue and Water Testing	Base N fertilizer amount and timing on crop needs and production goals. Before applying N early in the growth cycle, assess the amount of nitrate already present by soil (or soil solution) sampling and analysis. Use plant tissue sampling for mid- and late season fertilizer decisions. Measure nitrate levels in the irrigation water and adjust N fertilizer rate accordingly.
Application Timing	Determine the amount of nitrate already present in the soil. Apply N, P and K at a rate consistent with the crop nutrient requirements. Split applications of N fertilizer. Do not apply excessive single amounts of fertilizer N during the rainy season. For fertilizer application during fall, use only low N-containing materials such as $N:P_2O_5:K_2O$ equal to 1:3:3. Higher N materials may be appropriate if a crop is to be planted soon.
Fertilizer Placement	Place N fertilizer materials where maximum plant uptake will occur.
Irrigation	Adopt sprinkler irrigation. If fields are more than 1000 feet long, consider cutting the run length in half with a corresponding decrease in set time. Use high flow rates initially to get water down the field and then cut back to finish off the irrigation. Avoid doing the opposite. Collect surface water runoff for recirculation or reuse in other fields.
Application Practices	Clean-up fertilizer spills promptly. Shut off fertilizer applicators during turns and use check valves when possible. Maintain proper calibration of fertilizer application equipment. Whenever injecting fertilizer into irrigation water, ensure backflow does not occur. Rinse water from fertilizer tanks should be evenly spread throughout a field. Fertilizer tanks and equipment should be cleaned by rinsing in the field or at a properly designed wash facility. Rinse water and/or sludge should be evenly spread across a field using good agronomic practices. When equipment is parked, use care to prevent material from leaking into storage area. If equipment is known to be in disrepair, completely remove fertilizer material before parking equipment. When transferring fertilizer into on-farm storage or into a fertilizer applicator, take care not to allow materials to accumulate on the soil. Good housekeeping practices should be implemented to prevent contamination of groundwater and/or surface water.
Sediment Control BMPs	
Water and Sediment Control Basins	Constructed earth embankments or a combination ridge and channel. Constructed across the slope and minor watercourses to form a sediment trap and water detention basin.

	Benefits	Trap sediment and pesticides adsorbed to soil particles. Reduce and manage onsite and downstream runoff. Divert the flow of dissolved substances such as nutrients and pesticides. Improve the farmability of sloping land, reduce water course and gully erosion. Improve downstream water quality.
	Drawbacks	Basins are not viable for many orchard areas in California, primarily because considerable land acreage would be required to manage the volumes of water typically produced in rainfall events, especially in the Sacramento Valley.
PAM Applications	PAM is a polymer compound injected or fed into irrigation water at the head of a field supply ditch or discharge point. Applications rates range from 5-8 pounds per acre with the material typically metered into the head ditch with a gandy-type applicator	
	Benefits	In newly formed furrows, soil does not move down the row or erode when irrigation water is treated with PAM. Suspended soil particles drop out of irrigation water containing PAM. After an irrigation containing PAM, furrow erosion and transport of sediment is greatly reduced in subsequent irrigations. Erosion reductions of 95% have been documented in numerous field trials and commercial applications in the San Joaquin Valley.
	Drawbacks	Additional cost Is not effective in preventing solubilized pesticides from moving off-site.
Tailwater Return Systems	Benefits	Use of tailwater can offer substantial savings in irrigation power consumption if the water supply is groundwater. A tailwater recovery system increases yields because of higher irrigation efficiencies. A tailwater recovery system will not save all the tailwater, but it can increase irrigation efficiency by 25 to 30 percent.
	Drawbacks	The loss of the area required for a reuse pit and periodic maintenance of the pump, storage and return facilities.
Compaction / Wheel Rutting	Wheel ruts formed by equipment passing through wet fields can create channels for water and sediment to runoff from orchards. Where possible, minimize creation of wheel ruts with dormant orchard sprayers, brush shredders or other equipment when orchard floor is saturated.	
Drainage System Management	Filtering runoff water through vegetation allowed to grow in drainage ditches may help mitigate offsite movement of sediment as well as pesticides dissolved in storm runoff.	
Avoiding Channelization of Streams and Creeks	Allowing streams to naturally flow and meander can increase runoff retention and infiltration. A modified or channeled stream could also be restored to a more natural state by re-establishment of the riparian vegetation, which also provides stream bank protection.	
Berms at Low Ends of Fields (sandy soils, low slope)	Raised berms at low ends of fields can trap sediment and adsorbed pesticides reducing runoff of dissolved substances in fields with low slopes and sandy soil types. Berms hold back water, increasing runoff retention and allowing infiltration.	

Aeration	Use of specialized tillage equipment to break crusts and aerate soils with the intent of increasing water penetration and retention, thus reducing runoff. Aeration improves the soil profile with minimal disruption to the floor if completed during dormant season. Aeration may reduce OP pesticide runoff although no studies have been conducted.	
Improving soil texture (tilth)	Practices such as gypsum (or sulfur in higher lime soils) and humic acid applications or actions of earthworms have potential to increase water penetration and reduce runoff in compacted soils or where an impermeable soil layer exists. However, no studies have been conducted to show efficacy in reducing OP pesticide runoff with these approaches.	
	Benefits	Increased water penetration resulting in less runoff and increased recharging of the soil profile. Less water runoff means less potential for pesticides to be transported off-site.
	Drawbacks	Results vary with soil type and, under some conditions, compaction could increase. Improved soil permeability may increase movement of nitrate and other chemicals into groundwater. The balance of benefits versus disadvantages is not clear at this time and more research is needed.

Reference:

http://ipm.ucdavis.edu/PMG/selectnewpest.corn.html

Mixing and Loading Crop Sprayers, Tips and Techniques, Protecting Water Quality: Coalition for Urban/Rural Environmental Stewardship (http://www.curesworks.org)

Field and Row Crop Sprayers, Tips and Techniques, Protecting Water Quality: Coalition for Urban/Rural Environmental Stewardship (http://www.curesworks.org)

Crop: Dry Beans		
Compilation of Best Management Practices to Protect Surface Water from Farm Runoff		
Pesticide Application BMPs		
In-Season Sprays		
Improved Monitoring	Improved monitoring can lead to reduced sprays through "spray when necessary" rather than "calendar" timing. Base treatment decisions on sweeping and monitoring of the field.	
Organophosphates	Benefits	Excellent control of targeted insects.
	Drawbacks	Easily transported in water. Somewhat hard on beneficials though not to the same degree as pyrethroids.
Pyrethroids	**Benefits**	Excellent control of targeted insects. Not easily transported in water since they attach easily to soil particles
	Drawbacks	Resistance occurs quicker in pyrethroids than other classes of chemicals. Hard on beneficials leading to secondary pest outbreaks, especially aphids. Highly toxic to fish in solution. Can be transported off-site with sediment during rainfall or irrigation events.
Alternate Materials	Not a wide variety of alternate materials now available for major pests in dry beans. Please consult your PCA for more information.	
In-Season Spray BMPs		
Insecticides & Herbicides		
Drift	The ability to detect products in streams and rivers at parts per trillion levels leaves little room for error. To prevent problems, equipment operators must take extra care when spraying near sensitive areas and bodies of water. Shutoff equipment near windrow ends. Avoid applying when wind is blowing toward waterways or other sensitive areas. Leave buffer zone to protect sensitive areas. Use of larger droplet sizes. Use of drift retardant chemicals in the spray mix. Although these are effective in reducing the number of drift-prone droplets, in most cases it is more effective to select the proper size and type of nozzles and operate sprayers at low pressure to produce the desired drop size, rather than attempt to increase droplet size with drift retardant chemicals.	

Dry Beans Field Practice BMPs			
Cultural Practices	Lygus are likely to move when other food sources become unsuitable. Common weeds that are good hosts of lygus bugs include pigweed and wild radish. Nearby, mowed alfalfa fields are commonly a source of large numbers of lygus bug adults. Leaving areas of uncut alfalfa within or near the harvested area is attractive to lygus bug adults and may reduce the movement into neighboring fields. Scheduling alfalfa cutting to encourage a patchwork of cut and uncut fields may help keep lygus out of neighboring beans. A breeding program is underway to develop beans with host plant resistance to lygus bugs. For weevils, sanitation offers the most practical means of control. Since field infestations originate from beans, potential sources of weevils should be eliminated in production areas. Potential sources of weevils include broken sacks of seed beans left over from planting; seed beans left in planting hoppers; cull beans used in animal feed programs in a production area; small collections of beans remaining on or in a harvester following harvest; and small piles of beans remaining in or around the field after harvest or in a warehouse area. Reduce spider mite problems by keeping fields, field margins, and irrigation ditches clean of weed hosts. Spider mite populations may increase more rapidly in areas where dust deposits are heavy on bean plants. Thus, reducing dust may reduce the spider mite problem. Spider mites are usually less severe in sprinkler-irrigated fields than in furrow-irrigated fields. Minimizing early season insecticide applications, which may reduce populations of beneficials, will reduce spider mite outbreaks. Thrips populations tend to build up on weeds. Cultivating nearby weedy areas before beans emerge will reduce the potential of a thrips problem when the weeds begin to dry out. Cultivating weedy areas after bean emergence will increase thrips problems.		
Irrigation Runoff Management	**Catchment basins**	Benefits	Catchment basins with tailwater return systems can alleviate excess runoff preventing runoff from moving into surface waters. Water savings
		Drawbacks	Unlined catchment basins can contribute to downward movement of pesticides towards groundwater, so design is very crucial.
	Improved soil monitoring	Timing of irrigations is important so that moisture levels are not too high when irrigations occur, allowing for increased infiltration.	
	PAM Applications	PAM is a polymer compound injected or fed into irrigation water at the head of a field supply ditch or discharge point. Applications rates range from 5-8 pounds per acre with the material typically metered into the head ditch with a gandy-type applicator	
		Benefits	In newly formed furrows, soil does not move down the row or erode when irrigation water is treated with PAM. Suspended soil particles drop out of irrigation water containing PAM. After an irrigation containing PAM, furrow erosion and transport of sediment is greatly reduced in subsequent irrigations. Erosion reductions of 95% have been documented in numerous field trials and commercial applications in the San Joaquin Valley.

		Drawbacks	Additional cost. Is not effective in preventing solubilized pesticides from moving off-site.
	Sprinklers	Amount of water can be controlled and therefore runoff is more easily controlled.	
Vegetative Buffers	Areas or strips of land surrounding a field that are maintained in permanent vegetation. To effectively trap pesticides, buffers must slow water runoff and increase infiltration so that pesticides can be trapped and degraded in buffer soil and vegetation. Vegetative buffers are a tool to further improve water quality and provide additional benefits such as wildlife habitat and stream bank protection. For best success, they should be used in conjunction with other mitigation practices.		
	Benefits	Can be used to manage soil, water, nutrients and pesticides while minimizing environmental impacts. Effective in trapping eroded sediment, reducing runoff of pesticides that are adsorbed to soil particles. Note: some pesticides (e.g. OPs) are highly water soluble and don't adsorb to soil particles as readily as others (e.g. pyrethroids).	
	Drawbacks	California-based research is limited on the potential for filter strips and grassed waterways to reduce OP pesticide loading, although the practices have been shown to be effective in other regions of the U.S. Uncertainties of buffers include: appropriate dimensions for volume of water flow; appropriate plant species and plant density for the soil types and rainfall zones; considerations for various locations; slope and channel dimensions for grassed waterways; and dimensions for constructed wetlands. Can require growers to set aside productive acreage.	
Vegetative Filter Strips	Areas of grass or other permanent vegetation used to reduce sediment, organics, nutrients, pesticides and other contaminants in runoff to maintain or improve water quality. Vegetative filter strips are located between crop fields and water bodies, i.e. grassed roadways. Plant material captures rainfall and retains nutrients. Roadways can be grassed or sod planted, as can sprayer mixing pads and wellheads. Depending upon the site, a full border around a field may not be necessary for mitigating impacts to surface water. Filter strips could be planted at tail ends of fields or in other critical zones.		
	Benefits	Slows runoff allowing sediment to drop out of suspension. Traps sediment with adsorbed pesticide residues. Increases water infiltration into the soil profile. Catches some pesticide drift, preventing it from reaching the soil.	
	Drawbacks	If water runoff is channeled, a grass strip may not effectively trap the adsorbed pesticides.	
Grassed Waterways	Natural or constructed channels planted in permanent vegetation and located in an area where runoff concentrates. Constructed waterways can be graded to carry surface water at a non-erosive velocity to a stable outlet. Waterways are most effective in trapping sediment and dissolved chemicals when designed to spread concentrated water flow evenly cross a vegetative filter adjacent to waterways.		
	Benefits	Helps slow the flow of water to a non-erosive level. Provides a means of trapping sediment, nutrients, and pesticides while preventing gully erosion. Provides habitat and cover for wildlife.	

	Drawbacks	Overgrown channels causing waterway breaching and flooding can restrict storm flows. Due to the concentrated flow that normally occurs in waterways, sediment trapping and water infiltration can be minimal with large runoff events, but substantial with smaller events.
Filter Ditches	Areas filled with activated charcoal, peat, or other filtering agents at locations where water leaves the ranch. These would be replaced periodically and would filter pesticides before the soil solution reaches surface water.	
	Benefits	Further research is needed in California but other areas of the US have shown effective reduction of pesticide residue.
	Drawbacks	High cost due to materials and increased maintenance needed.
Riparian Buffers	Trees and shrubs planted adjacent to streams, lakes, ponds and wetlands. Forest buffers are frequently combined with an understory of perennial grass buffers.	
	Benefits	Helps lower water temperatures by shading the water body. Protects stream banks and slows out-of-bank flood flows. Deep tree roots may intercept nitrate entering streams in shallow subsurface flow and provide soil carbon for microbial energy. Microbes can denitrify nitrate and degrade pesticides. Woody vegetation provides food and cover for wildlife. Contributes energy sources to aquatic communities.
	Drawbacks	If water runoff is channeled, riparian buffers may not effectively trap pesticides.
Constructed Wetlands	Wetlands constructed at tile outlets or as part of riparian buffer systems for degrading pesticides and denitrifying nitrates.	
	Benefits	Provides confined area for breakdown of pesticides in water.
	Drawbacks	Land needed for constructed wetlands is not readily available in high production areas. Available land can be costly.
Hedgerows	Fences of shrubs or trees in, across, or around a field. Hedgerows can include an understory composed of perennial native grasses and forbs, a shrub midstory composed of California native species and occasionally a discontinuous overstory of valley and foothill trees.	
	Benefits	May reduce erosion by having perennial vegetation on a portion of the field. If runoff flows across the hedgerow in sheet flow, sediment can be trapped, reducing the amount of sediment and sediment-borne pesticides from entering surface waters. Can attract beneficial insects and provide competition against invasive weeds. Windbreaks and hedgerows can provide drift mitigation, potentially reducing off-site movement of pesticides. Because many of the native species used in hedgerows have deep roots that hold the soil and increase water permeability, there may be a reduction in water runoff and off site movement of sediment. This could reduce runoff of pesticides in the dissolved and sediment-borne phases of field runoff. However, no studies have quantitatively measured the reductions in OP pesticide runoff.

	Drawbacks	Certain plant species may attract pests that can attack the crop or neighboring crops. Careful consideration must be given to the species of vegetation selected and the types of insects that may be attracted. Plant species can provide habitat and attract endangered species. Safe Harbor Agreements are available to protect growers where a practice is implemented that could attract endangered species to their farms, a factor that should be evaluated and addressed before establishing hedgerows. Some species can grow 10-15 feet wide, so space must be allowed for equipment to pass.
Stewardship BMPs		
Mixing / Loading/Cleanup		
Concrete or Asphalt Pad	Use concrete or asphalt pad that drains to a central sump	
Proximity of mixing/loading area	Take precautions to insure that the minimum distance between any mixing/loading area and any ditches, canals or streams that feed into nearby rivers is at least 100 feet. Take precautions to insure that the minimum distance between any mixing/loading area and pump is at least 100 feet.	
Equipment	Check equipment for cracked / broken hoses, valves, etc. Calibrate prior to each application. Use spray nozzles with large droplet size to minimize drift.	
Tank filling	Fill tank to 1/3 to ½ full prior to the addition of chemicals. Use air gap to prevent tank overfilling. Use backflow valve on the fill tube.	
Personnel	Person(s) always present during mixing/loading operations. Person(s) trained to take corrective action when necessary.	
Storage Areas	Have spill containment capability to protect from runoff into any nearby surface waters. Use impermeable surface (coated or sealed concrete) with curbs for floors.	
Cleanup	Mix rinseate with water and reapply to field. Clean equipment on appropriate pad at least 300 feet from surface waters. Triple rinse empty containers and dispose of in landfill or recycling area.	
Nutrient/Fertilizer Application BMPs		
Soil, Tissue and Water Testing	Base N fertilizer amount and timing on crop needs and production goals. Before applying N early in the growth cycle, assess the amount of nitrate already present by soil (or soil solution) sampling and analysis. Use plant tissue sampling for mid- and late season fertilizer decisions. Measure nitrate levels in the irrigation water and adjust N fertilizer rate accordingly.	

Application Timing	Determine the amount of nitrate already present in the soil. Apply N, P and K at a rate consistent with the crop nutrient requirements. Split applications of N fertilizer. Do not apply excessive single amounts of fertilizer N during the rainy season. For fertilizer application during fall, use only low N-containing materials such as $N:P_2O_5:K_2O$ equal to 1:3:3. Higher N materials may be appropriate if a crop is to be planted soon.	
Fertilizer Placement	Place N fertilizer materials where maximum plant uptake will occur.	
Irrigation	Adopt sprinkler irrigation. If fields are more than 1000 feet long, consider cutting the run length in half with a corresponding decrease in set time. Use high flow rates initially to get water down the field and then cut back to finish off the irrigation. Avoid doing the opposite. Collect surface water runoff for recirculation or reuse in other fields.	
Application Practices	Clean-up fertilizer spills promptly. Shut off fertilizer applicators during turns and use check valves when possible. Maintain proper calibration of fertilizer application equipment. Whenever injecting fertilizer into irrigation water, ensure backflow does not occur. Rinse water from fertilizer tanks should be evenly spread throughout a field. Fertilizer tanks and equipment should be cleaned by rinsing in the field or at a properly designed wash facility. Rinse water and/or sludge should be evenly spread across a field using good agronomic practices. When equipment is parked, use care to prevent material from leaking into storage area. If equipment is known to be in disrepair, completely remove fertilizer material before parking equipment. When transferring fertilizer into on-farm storage or into a fertilizer applicator, take care not to allow materials to accumulate on the soil. Good housekeeping practices should be implemented to prevent contamination of groundwater and/or surface water.	
Sediment Control BMPs		
Water and Sediment Control Basins	Constructed earth embankments or a combination ridge and channel. Constructed across the slope and minor watercourses to form a sediment trap and water detention basin.	
	Benefits	Trap sediment and pesticides adsorbed to soil particles. Reduce and manage onsite and downstream runoff. Divert the flow of dissolved substances such as nutrients and pesticides. Improve the farmability of sloping land, reduce water course and gully erosion. Improve downstream water quality.
	Drawbacks	Basins are not viable for many orchard areas in California, primarily because considerable land acreage would be required to manage the volumes of water typically produced in rainfall events, especially in the Sacramento Valley.

PAM Applications	PAM is a polymer compound injected or fed into irrigation water at the head of a field supply ditch or discharge point. Applications rates range from 5-8 pounds per acre with the material typically metered into the head ditch with a gandy-type applicator	
	Benefits	In newly formed furrows, soil does not move down the row or erode when irrigation water is treated with PAM. Suspended soil particles drop out of irrigation water containing PAM. After an irrigation containing PAM, furrow erosion and transport of sediment is greatly reduced in subsequent irrigations. Erosion reductions of 95% have been documented in numerous field trials and commercial applications in the San Joaquin Valley.
	Drawbacks	Additional cost Is not effective in preventing solubilized pesticides from moving off-site.
Tailwater Return Systems	Benefits	Use of tailwater can offer substantial savings in irrigation power consumption if the water supply is groundwater. A tailwater recovery system increases yields because of higher irrigation efficiencies. A tailwater recovery system will not save all the tailwater, but it can increase irrigation efficiency by 25 to 30 percent.
	Drawbacks	The loss of the area required for a reuse pit and periodic maintenance of the pump, storage and return facilities.
Compaction / Wheel Rutting	Wheel ruts formed by equipment passing through wet fields can create channels for water and sediment to runoff from orchards. Where possible, minimize creation of wheel ruts with dormant orchard sprayers, brush shredders or other equipment when orchard floor is saturated.	
Drainage System Management	Filtering runoff water through vegetation allowed to grow in drainage ditches may help mitigate offsite movement of sediment as well as pesticides dissolved in storm runoff.	
Avoiding Channelization of Streams and Creeks	Allowing streams to naturally flow and meander can increase runoff retention and infiltration. A modified or channeled stream could also be restored to a more natural state by re-establishment of the riparian vegetation, which also provides stream bank protection.	
Berms at Low Ends of Fields (sandy soils, low slope)	Raised berms at low ends of fields can trap sediment and adsorbed pesticides reducing runoff of dissolved substances in fields with low slopes and sandy soil types. Berms hold back water, increasing runoff retention and allowing infiltration.	
Aeration	Use of specialized tillage equipment to break crusts and aerate soils with the intent of increasing water penetration and retention, thus reducing runoff. Aeration improves the soil profile with minimal disruption to the floor if completed during dormant season. Aeration may reduce OP pesticide runoff although no studies have been conducted.	
Improving soil texture (tilth)	Practices such as gypsum (or sulfur in higher lime soils) and humic acid applications or actions of earthworms have potential to increase water penetration and reduce runoff in compacted soils or where an impermeable soil layer exists. However, no studies have been conducted to show efficacy in reducing OP pesticide runoff with these approaches.	
	Benefits	Increased water penetration resulting in less runoff and increased recharging of the soil profile. Less water runoff means less potential for pesticides to be transported off-site.

	Drawbacks	Results vary with soil type and, under some conditions, compaction could increase. Improved soil permeability may increase movement of nitrate and other chemicals into groundwater. The balance of benefits versus disadvantages is not clear at this time and more research is needed.

Reference:

http://ipm.ucdavis.edu/PMG/selectnewpest.beans.html

Mixing and Loading Crop Sprayers, Tips and Techniques, Protecting Water Quality: Coalition for Urban/Rural Environmental Stewardship (http://www.curesworks.org)

Field and Row Crop Sprayers, Tips and Techniques, Protecting Water Quality: Coalition for Urban/Rural Environmental Stewardship (http://www.curesworks.org)

Crop: Peaches	
Compilation of Best Management Practices to Protect Surface Water from Farm Runoff	
Pesticide Application BMPs	
Dormant Season Sprays	
Monitoring	Monitoring is critical because treatment may not be needed some years if monitoring indicates an absence of the pest. If orchard has history of worm damage, it is not recommended to skip the dormant spray. However, if no dormant spray is applied, monitor for peach twig borer larvae associated with blooms or emerging shoots, as well as twig strikes resulting from feeding by the emerging larvae. If larvae are observed associated with blooms or emerging shoots, Bacillus thuringiensis (Bt) can be applied during bloom. Once strikes are observed, it is probably too late for bloom time Bt sprays to be effective. Monitor peach twig larvae at bloom and when shoots are emerging. If larvae are observed at this time, two sprays of Bt or a single treatment of spinosad can be applied. Bt sprays at bloom can also be timed by dissecting hibernacula regularly from late February through bloom. The increase in the number of empty hibernacula reflects the number of larvae that have emerged and can be controlled by Bt once foliage is present. After bloom, Bt is not effective for peach twig borer.
Pesticide Application BMPs	
Dormant Season Sprays	
Dormant Diazinon and Oil Spray	Diazinon combined with dormant oil during the dormant season. Diazinon applications are frequently alternated with non-OP pesticides to prevent resistance from developing to either diazinon or non-OP pesticides. Information is being developed on earlier timing of winter OP applications when less rainfall is likely or when the rainfall is more likely to be absorbed into the soil rather than runoff. Reduced rates: additional data is needed to demonstrate effects at varying pest (aphid) densities.
No Dormant Treatment or Dormant Oil Only Treatment	Dormant insecticide spray is not applied or an oil only treatment is made. Additional in-season treatments for mites may be necessary following in-season applications of carbaryl, esfenvalerate and permethrin to peaches and nectarines.
Alternate Year Dormant OP Pesticide With Yearly Oil Spray	Use dormant OP every other year but use dormant oil on an annual basis. Lower rates may be used if San Jose scale is not present. In years with no dormant OP used the following may be necessary: Additional in-season treatments for peach twig borer in peaches and nectarines. Additional in-season treatments for mites following in-season applications of carbaryl, esfenvalerate and permethrin to peaches and nectarines.

Dormant Spray (Non-OP Pesticides) and Oil	Pyrethroids (permethrin and esfenvalerate) and carbamates (carbaryl) for peach twig borer in the delayed-dormant or dormant season. Pyrethroids are not as effective as an OP pesticide and oil spray for controlling San Jose scale during the dormant season. Another approach should be considered if moderate to high San Jose scale populations are present. Residues of the pyrethroid insecticides permethrin and esfenvalerate persist on bark and may impact naturally occurring predator mites for extended periods of time after dormant season and in-season applications. Mite outbreaks caused by use of pyrethroids may require additional miticide treatments over and above those normally applied. While pyrethroids remain effective for controlling peach twig borers in most areas, greatly increased tolerance by peach twig borer to pyrethroids has been identified in the Sacramento Valley, raising the possibility of resistance. In general, insects become resistant to pyrethroids more rapidly than other classes of pesticides. Some registered products are not widely used in the dormant season because of possible effects on non-target organisms or because of label restrictions. For example, carbaryl cannot be used in orchards where honeybees are present and endosulfan use is restricted near water or wetlands. Non-OP pesticides can affect non-target organisms in water and the potential for offsite movement from runoff has not been well studied. If a non-OP pesticide is applied as a dormant spray, precautions such as on-site practices (following sections) should be taken to prevent movement into surface waters. Laboratory exposures indicate that fish and invertebrates are particularly sensitive to pyrethroids. Pyrethroid persistence may mean that they will be transported off site. If so, they may be bioavailable to fish in water or to invertebrates in sediment. Sediment toxicity may result after pyrethroids are transported into water bodies.
Spinosad and Oil as Dormant Spray	Spinosad (Success Naturalyte insect control) is a low-risk pesticide for control of peach twig borer. However, it is not effective for San Jose scale or aphids. Dormant prunings should be examined to determine if San Jose scale populations require treatment. Peach twig borer shoot strikes should be monitored in each generation as well as the presence of larvae as fruit starts to ripen. If monitoring indicates that any of the pest species require additional control measures, they can be applied in-season. Additional in-season treatments for peach twig borer in peaches and nectarines may be necessary.
Bloomtime Sprays of Bacillus thuringiensis (Bt) For Peach Twig Borer.	Treatments of Bt at bloom to control over-wintering peach twig borer larvae. Peaches and nectarines: A dormant oil and Bt program may not control peach twig borer to below economic levels. Additional in-season treatments may be needed. This strain of Bt only effects larvae of butterflies and moths and is not considered harmful to humans, pest parasites, predators or aquatic species. Bt will not control San Jose scale. Additional treatments are often necessary in peach and nectarine orchards. Dormant prunings should be examined to determine if San Jose scale populations require treatment. Peach twig borer shoot strikes should be monitored in each generation, as well as the presence of larvae as fruit start to ripen. If monitoring indicates that any of the pest species require additional control measures, treatments can be applied in-season.

Pheromone Mating Disruption for Peach Twig Borer	Mating disruption relies on releasing pheromones through dispensers distributed throughout an orchard or applied as a spray. It has been shown to be effective against peach twig borer in peach and nectarine orchards (although some details of application and effective rates of specific products are incomplete). It is most effective in orchards with low moth populations that are not close to other untreated peach twig borer hosts or other orchards. Efficacy is reduced by small orchard size, uneven terrain, reduced pheromone application rates, applying too low in the tree, improper timing, and high insect pressure. Pheromone mating disruption cannot be considered a stand-alone system. It is selective for the target pest so monitoring for other orchard pests as well as peach twig borer is necessary.
Dormant Season Spray BMPs	
Restrict dormant spray applications (except oil alone) to ground applications only. Do not apply within 100 feet upslope of any sensitive aquatic site that may drain into a river or tributary unless runoff is contain or diverted from the sensitive aquatic site. Waters that are contained or diverted must be held for 72 hours before they can be released into a sensitive aquatic site. Maintain a vegetative buffer strip a minimum of 10 feet wide from the edge of the field to sensitive aquatic sites. Do not apply dormant sprays (except oil alone) when soil moisture is at field capacity and a storm is predicted in the next 48 hours. Do not apply dormant sprays (except oil alone) when surface runoff to sensitive aquatic sites from a rain event could occur within 48 hours after the application. Make dormant applications only when insect-scouting information indicates pest populations have reached damaging levels. (See University of California Integrated Pest Management Guidelines for peaches.) Apply only when wind speed is 3-10 mph at the application site as measured by an anemometer outside of the orchard on the upwind side. When air currents are moving (>3 mph) toward sensitive aquatic sites, commence applications on side nearest the site and proceed spraying away from the water body. Spray last three rows upwind of bodies of water using nozzles on one side only, with spray directed away from sensitive aquatic sites. Reduce the maximum rate of application and the number of applications. Alternate the dormant use of organophosphorous and pyrethroid insecticides with other environmentally reduced risk pesticides or make application in season according to University of California Integrated Pest Management recommendations.	
Dormant Orchard Field Practice BMPs	
Orchard Floor Vegetation During Dormant Season	Seeded or resident vegetation growing on orchard floors that is later mowed or disked. Resident Vegetation - existing, unplanted mixture of annual or perennial weeds, crop species and/or native grasses and forbs which has adapted to management methods used in the orchard. Seeded vegetation - cover crops that include many types of cultivated species including legumes (bell beans, peas, clover, medics and vetches) and grasses such as cereal grains, turf grasses and sudan grass.

	Resident or Seeded Vegetation (continued)	Benefits	Orchard floor vegetation can reduce dormant spray pesticide runoff to surface waters in several ways: - Can be easily encouraged to grow in the fall or early winter by a post harvest irrigation or early rains and requires little to no management to establish. - Reduction in runoff volume through increased water infiltration. - Reduction in sheet erosion caused by rainfall impact on bare ground. - Decrease in pesticide mass carried by sediment. - Shorter pesticide persistence (faster breakdown) on vegetation than soil. - Adsorption of pesticides to plant surfaces. - Anchors soil during winter rains preventing soil, nutrient and pesticide runoff. - Allows pesticides to break down and be filtered onsite. Adds organic material to the soil. Accelerates the biodegradation of pesticides in soil. Can reduce plant parasitic nematodes by antagonism. Legume cover crops fix atmospheric nitrogen and release it to the orchard crop during the growing season. Improves water infiltration, soil aeration and soil texture. Improves soil fertility. Assists in weed control (seeded covers). Improves orchard access during wet weather. Cover crops provide nectar sources, pollen and prey for beneficial predators. Stone fruit orchards (apricots, cherries, peaches, plums) can support a full perennial sod of grasses or clover. Approximately 6% of California dried plum acreage contains permanent sod cover crops.

		Drawbacks	Difficult to manage if noxious weeds are present and requires mechanical or herbicide control in late winter or early spring if overgrown. Increased cover and feed for gophers, ground squirrels and mice (also higher populations from increased habitat and reduced predation). Increased humidity can potentially create conditions for fungal diseases. Potentially increased nematode populations with summer-grown cover crop. Higher water use with perennial cover crops. Sprinklers can be blocked by climbing vetches. Blooming cover crops can compete with tree crops for pollinator insects if not mowed. Increased danger of frost damage. A tall, dense cover crop can reduce nighttime temperatures by up to 5 or 6 degrees, increasing the potential for frost damage. However, orchards with closely mowed cover crops and moist soil may be only about 1 degree colder than bare soil. Alternate row cover cropping can reduce the difference even more. Mowing before frost reduces the risk of frost damage.
Cover Crop Management	**Cover and Green Manure Crop**	Plants are disked to incorporate organic material and improve soil fertility and tilth. Disking (or mowing) is generally done when plants are in full-bloom to post-bloom stage, depending on frost potential and soil moisture conditions.	
	Mowed Cover Crop	Managed by mowing to maintain at least 60% ground cover where erosion is possible. Mowing to 3-4 inches prior to frost can reduce cold temperature damage potential. Mowing intervals can often allow adequate seed production for following season re-growth. Mowed cover crops reduce dust during harvest operations and improve water infiltration rates.	
	Disked Cover Crop	Plants typically disked at full-bloom to post-bloom stage, depending on condition of the target crop, weather and soil moisture conditions. Maintain at least 60% ground cover where erosion is possible. Mowing to 3-4 inches prior to frost can reduce potential for cold temperature damage.	
Vegetative Buffers	Areas or strips of land surrounding an orchard that are maintained in permanent vegetation. To effectively trap pesticides, buffers must slow water runoff and increase infiltration so that pesticides can be trapped and degraded in buffer soil and vegetation. Vegetative buffers are a tool to further improve water quality and provide additional benefits such as wildlife habitat and stream bank protection. For best success, they should be used in conjunction with other mitigation practices.		
	Benefits	Can be used to manage soil, water, nutrients and pesticides while minimizing environmental impacts. Effective in trapping eroded sediment, reducing runoff of pesticides that are adsorbed to soil particles. Note: some pesticides (e.g. OPs) are highly water soluble and don't adsorb to soil particles as readily as others (e.g. pyrethroids).	

	Drawbacks	California-based research is limited on the potential for orchard filter strips and grassed waterways to reduce OP pesticide loading, although the practices have been shown to be effective in other regions of the U.S. Uncertainties of buffers include: appropriate dimensions for volume of water flow; appropriate plant species and plant density for the soil types and rainfall zones; considerations for various locations; slope and channel dimensions for grassed waterways; and dimensions for constructed wetlands. Can require growers to set aside productive acreage.
Vegetative Filter Strips	Areas of grass or other permanent vegetation used to reduce sediment, organics, nutrients, pesticides and other contaminants in runoff to maintain or improve water quality. Vegetative filter strips are located between crop fields and water bodies, i.e. grassed roadways. Plant material captures rainfall and retains nutrients. Roadways can be grassed or sod planted, as can sprayer mixing pads and wellheads. Depending upon the site, a full border around an orchard may not be necessary for mitigating impacts to surface water. Filter strips could be planted at low ends of fields or in other critical zones.	
	Benefits	Slows runoff allowing sediment to drop out of suspension. Traps sediment with adsorbed pesticide residues. Increases water infiltration into the soil profile. Catches some pesticide drift, preventing it from reaching the soil.
	Drawbacks	If water runoff is channeled, a grass strip may not effectively trap the adsorbed pesticides.
Vegetative Barriers	Narrow, permanent strips of stiff stemmed, erect, dense, perennial vegetation established in parallel rows and perpendicular to the dominant slope of the field.	
	Benefits	Effective in dispersing concentrated flow, thus increasing sediment trapping and water infiltration.
	Drawbacks	If water runoff is channeled, a vegetative barrier may not effectively trap the adsorbed pesticides.
Grassed Waterways	Natural or constructed channels planted in permanent vegetation and located in an area where runoff concentrates. Constructed waterways can be graded to carry surface water at a non-erosive velocity to a stable outlet. Waterways are most effective in trapping sediment and dissolved chemicals when designed to spread concentrated water flow evenly cross a vegetative filter adjacent to waterways.	
	Benefits	Helps slow the flow of water to a non-erosive level. Provides a means of trapping sediment, nutrients, and pesticides while preventing gully erosion. Provides habitat and cover for wildlife.
	Drawbacks	Overgrown channels causing waterway breaching and flooding can restrict storm flows. Due to the concentrated flow that normally occurs in waterways, sediment trapping and water infiltration can be minimal with large runoff events, but substantial with smaller events.
Riparian Buffers	Trees and shrubs planted adjacent to streams, lakes, ponds and wetlands. Forest buffers are frequently combined with an understory of perennial grass buffers.	

	Benefits	Helps lower water temperatures by shading the water body. Protects stream banks and slows out-of-bank flood flows. Deep tree roots may intercept nitrate entering streams in shallow subsurface flow and provide soil carbon for microbial energy. Microbes can denitrify nitrate and degrade pesticides. Woody vegetation provides food and cover for wildlife. Contributes energy sources to aquatic communities.
	Drawbacks	If water runoff is channeled, riparian buffers may not effectively trap pesticides.
Constructed Wetlands	Wetlands constructed at tile outlets or as part of riparian buffer systems for degrading pesticides and denitrifying nitrates.	
	Benefits	Provides confined area for breakdown of pesticides in water.
	Drawbacks	Land needed for constructed wetlands is not readily available in high production areas. Available land can be costly.
Hedgerows	Fences of shrubs or trees in, across, or around a field. Hedgerows can include an understory composed of perennial native grasses and forbs, a shrub midstory composed of California native species and occasionally a discontinuous overstory of valley and foothill trees.	
	Benefits	May reduce erosion by having perennial vegetation on a portion of the field. If runoff flows across the hedgerow in sheet flow, sediment can be trapped, reducing the amount of sediment and sediment-borne pesticides from entering surface waters. Can attract beneficial insects and provide competition against invasive weeds. Windbreaks and hedgerows can provide drift mitigation, potentially reducing off-site movement of pesticides. Because many of the native species used in hedgerows have deep roots that hold the soil and increase water permeability, there may be a reduction in water runoff and off site movement of sediment. This could reduce runoff of pesticides in the dissolved and sediment-borne phases of field runoff. However, no studies have quantitatively measured the reductions in OP pesticide runoff.
	Drawbacks	Certain plant species may attract pests that can attack the crop or neighboring crops. Careful consideration must be given to the species of vegetation selected and the types of insects that may be attracted. Plant species can provide habitat and attract endangered species. Safe Harbor Agreements are available to protect growers where a practice is implemented that could attract endangered species to their farms, a factor that should be evaluated and addressed before establishing hedgerows. Some species can grow 10-15 feet wide, so space must be allowed for equipment to pass.

Reducing or Eliminating the Herbicide-Sprayed Berm	Berm areas of orchards sprayed with herbicides represent a bare conduit for runoff of rainfall or irrigation water. By allowing vegetation to grow and reducing the berm width or seasonal spraying of the berm, runoff potential from an orchard could be reduced. Options - Reduce strip spray widths by 25%. - Apply herbicide in January/February after sprouted grass covers the berm. - Spray a 5-foot square block around trees to keep the trunk area clean but leave vegetation on the remainder of the row berm. - Stop spraying herbicides at the next-to-the-last tree in each row, leaving a vegetative barrier surrounding the orchard. - Eliminate use of pre-emergence herbicides.	
	Benefits	Cost Savings Reduction in runoff volume through increased soil infiltration. Decrease in soil erosion and movement of pesticides with soil borne runoff. Shorter pesticide persistence on vegetation than soil and better absorption on plant surfaces (faster degradation on plant matter). An orchard floor that is completely vegetated versus 25% bare soil has greater area for these mechanisms to function.
	Drawbacks	Vegetation control can be difficult if excessive growth occurs before herbicide is applied.
In-Season Spray BMPs		
Insecticides & Herbicides		
Monitoring	If several (3 to 5) twig strikes are seen on each tree by mid-April, in-season sprays should be applied for peach twig borer control timed to pheromone trap catches and the phenology model for peach twig borer. Continue monitoring after bloom by checking for the number of shoot strikes at the end of each generation and treat if there is more than an average of three to five strikes per tree. About 4 weeks before harvest when fruit begins to ripen, take weekly fruit samples. Check fruit on border trees; apply a spray immediately if larvae are found entering the fruit.	
Drift	The ability to detect products in streams and rivers at parts per trillion levels leaves little room for error. To prevent problems, equipment operators must take extra care when spraying near sensitive areas and bodies of water. Shutoff equipment when making row turns. Avoid spraying when wind is blowing toward waterways or other sensitive areas. Leave buffer zone to protect sensitive areas.	
Managing Irrigation Runoff	Tailwater return systems can alleviate excess runoff preventing runoff from moving into surface waters. Use vegetative barriers (see dormant orchard field practices) to filter runoff prior to leaving site. Use of drip irrigation, especially buried drip has reduced or eliminated irrigation-induced runoff.	

Cultural Controls	Reduce dusty conditions in orchards by oiling or watering roadways and maintaining a groundcover. Prevent water stress, as this condition results in higher mite populations and makes trees more susceptible to damage. The use of broad-spectrum materials in-season, such as pyrethroids, carbamates, and organophosphates (unless organophosphate-resistant predator mites are present in the orchard); will often result in spider mite outbreaks.
Stewardship BMPs	
Mixing / Loading/Cleanup	
Concrete or Asphalt Pad	Use concrete or asphalt pad that drains to a central sump
Proximity of mixing/loading area	Take precautions to insure that the minimum distance between any mixing/loading area and any ditches, canals or streams that feed into nearby rivers is at least 100 feet. Take precautions to insure that the minimum distance between any mixing/loading area and pump is at least 100 feet.
Equipment	Check equipment for cracked / broken hoses, valves, etc. Calibrate prior to each application. Use spray nozzles adjusted for crop canopy. Use nozzles with large droplet size to minimize drift.
Tank filling	Fill tank to 1/3 to ½ full prior to the addition of chemicals. Use air gap to prevent tank overfilling. Use backflow valve on the fill tube.
Personnel	Person(s) always present during mixing/loading operations. Person(s) trained to take corrective action when necessary.
Storage Areas	Have spill containment capability to protect from runoff into any nearby surface waters. Use impermeable surface (coated or sealed concrete) with curbs for floors.
Cleanup	Mix rinseate with water and reapply to field. Clean equipment on appropriate pad at least 300 feet from surface waters. Triple rinse empty containers and dispose of in landfill or recycling area.
Nutrient/Fertilizer Application BMPs	
Soil, Tissue and Water Testing	Base N fertilizer amount and timing on crop needs and production goals. Before applying N early in the growth cycle, assess the amount of nitrate already present by soil (or soil solution) sampling and analysis. Use plant tissue sampling for mid- and late season fertilizer decisions. Measure nitrate levels in the irrigation water and adjust N fertilizer rate accordingly.

Application Timing	When applying manure shortly before a crop is planted, determine the nutrient content of the manure and the amount of nitrate already present in the soil. Apply manure at a rate consistent with the crop nutrient requirements. Split applications of N fertilizer. No not apply excessive single amounts of fertilizer N during the rainy season. For fertilizer application during fall tillage, use only low N-containing materials such as $N:P_2O_5:K_2O$ equal to 1:3:3. Higher N materials may be appropriate if a crop is to be planted soon.
Fertilizer Placement	Place N fertilizer materials where maximum plant uptake will occur. Incorporate N fertilizer into the crop bed by either placing fertilizer on or near the seed row and watering it in, knifing fertilizer into the bed or broadcasting fertilizer then listing it up into the bed. Incorporate manures and other organic amendments into soil with consideration of the timing of conversion of manure N to other forms.
Irrigation	Adopt surge irrigation. Improve irrigation uniformity by turning irrigation water on and off as it flows down the furrow. If fields are more than 1000 feet long, consider cutting the furrow run length in half with a corresponding decrease in set time. Use high flow rates initially to get water down the field and then cut back to finish off the irrigation. Avoid doing the opposite. Use practices that increase uniformity among furrows (e.g. torpedoes, extra tractor trips, etc.) Collect surface water runoff for recirculation or reuse in other fields.
Application Practices	Clean-up fertilizer spills promptly. Shut off fertilizer applicators during turns and use check valves when possible. Maintain proper calibration of fertilizer application equipment. Whenever injecting fertilizer into irrigation water, ensure backflow does not occur. Rinse water from fertilizer tanks should be evenly spread throughout a field. Fertilizer tanks and equipment should be cleaned by rinsing in the field or at a properly designed wash facility. Rinse water and/or sludge should be evenly spread across a field using good agronomic practices. When equipment is parked, use care to prevent material from leaking into storage area. If equipment is known to be in disrepair, completely remove fertilizer material before parking equipment. When transferring fertilizer into on-farm storage or into a fertilizer applicator, take care not to allow materials to accumulate on the soil. Good housekeeping practices should be implemented to prevent contamination of groundwater and/or surface water.
Cover Crops	If conditions permit, grow a cover crop to use excess nitrogen and prevent leaching rather than leaving fields fallow during the rainy season.
Sediment Control BMPs	
Water and Sediment Control Basins	Constructed earth embankments or a combination ridge and channel. Constructed across the slope and minor watercourses to form a sediment trap and water detention basin.

	Benefits	Trap sediment and pesticides adsorbed to soil particles. Reduce and manage onsite and downstream runoff. Divert the flow of dissolved substances such as nutrients and pesticides. Improve the farmability of sloping land, reduce water course and gully erosion. Improve downstream water quality.
	Drawbacks	Basins are not viable for many orchard areas in California, primarily because considerable land acreage would be required to manage the volumes of water typically produced in rainfall events, especially in the Sacramento Valley.
PAM Applications	PAM is a polymer compound injected or fed into irrigation water at the head of a field supply ditch or discharge point. Applications rates range from 5-8 pounds per acre with the material typically metered into the head ditch with a gandy-type applicator	
	Benefits	In newly formed furrows, soil does not move down the row or erode when irrigation water is treated with PAM. Suspended soil particles drop out of irrigation water containing PAM. After an irrigation containing PAM, furrow erosion and transport of sediment is greatly reduced in subsequent irrigations. Erosion reductions of 95% have been documented in numerous field trials and commercial applications in the San Joaquin Valley.
	Drawbacks	Additional cost
Tailwater Return Systems	**Benefits**	Use of tailwater can offer substantial savings in irrigation power consumption if the water supply is groundwater. A tailwater recovery system increases yields because of higher irrigation efficiencies. A tailwater recovery system will not save all the tailwater, but it can increase irrigation efficiency by 25 to 30 percent.
	Drawbacks	The loss of the area required for a reuse pit and periodic maintenance of the pump, storage and return facilities.
Compaction / Wheel Rutting	Wheel ruts formed by equipment passing through wet fields can create channels for water and sediment to runoff from orchards. Where possible, minimize creation of wheel ruts with dormant orchard sprayers, brush shredders or other equipment when orchard floor is saturated.	
Drainage System Management	Filtering runoff water through vegetation allowed to grow in drainage ditches may help mitigate offsite movement of sediment as well as pesticides dissolved in storm runoff.	
Avoiding Channelization of Streams and Creeks	Allowing streams to naturally flow and meander can increase runoff retention and infiltration. A modified or channeled stream could also be restored to a more natural state by re-establishment of the riparian vegetation, which also provides stream bank protection.	
Berms at Low Ends of Fields (sandy soils, low slope)	Raised berms at low ends of fields can trap sediment and adsorbed pesticides reducing runoff of dissolved substances in fields with low slopes and sandy soil types. Berms hold back water, increasing runoff retention and allowing infiltration.	

Planting 90 degrees to Grade	Planting orchards and performing tractor work 90 degrees to the grade to reduce erosion and provide for greater water penetration and retention. Practice is very site-specific and would not be easily adaptable to many existing orchards, particularly those that are flood irrigated.	
Aeration	Use of specialized tillage equipment to break crusts and aerate orchard soils with the intent of increasing water penetration and retention, thus reducing runoff. Aeration improves the soil profile with minimal disruption to the orchard floor. Aeration may reduce OP pesticide runoff although no studies have been conducted.	
Ripped Resident Vegetation	In orchards with permanent or semi-permanent sod, vegetation is ripped at various lengths and/or depths. Ripping significantly increases soil water due to increased infiltration and porosity. Heavy rains after fall ripping can leave orchards impassable to heavy equipment such as orchard sprayers. For stone fruits, shank depth must be shallow to avoid damage to tree roots. In recent research, ripped resident vegetation performed the best for infiltration and reduced diazinon transport, followed by non-ripped resident vegetation and bare ground being the least effective.	
Improving soil texture (tilth)	Practices such as tillage, gypsum applications or actions of earthworms have potential to increase water penetration and reduce runoff in compacted soils or where an impermeable soil layer exists. However, no studies have been conducted to show efficacy in reducing OP pesticide runoff with these approaches.	
	Benefits	Increased water penetration resulting in less runoff and increased recharging of the soil profile. Less water runoff means less potential for pesticides to be transported off-site.
	Drawbacks	Tillage can increase erosion under some conditions and necessitate additional orchard floor finishing work (scraping). Results vary with soil type and, under some conditions, compaction could increase. Improved soil permeability may increase movement of nitrate and other chemicals into groundwater. The balance of benefits versus disadvantages is not clear at this time and more research is needed.

Reference:

Integrated Pest Management for Stone Fruits: University of California Statewide IPM Project. 1999. 264pp.

http://ipm.ucdavis.edu/PMG/selectnewpest.peach.html

Orchard Practices for Protecting Surface Water: Coalition for Urban/Rural Environmental Stewardship (http://www.curesworks.org)

Mixing and Loading Crop Sprayers, Tips and Techniques, Protecting Water Quality: Coalition for Urban/Rural Environmental Stewardship (http://www.curesworks.org)

Field and Row Crop Sprayers, Tips and Techniques, Protecting Water Quality: Coalition for Urban/Rural Environmental Stewardship (http://www.curesworks.org)

Crop: Tomato		
Compilation of Best Management Practices to Protect Surface Water from Farm Runoff		
Pesticide Application BMPs		
In-Season Sprays		
Improved Monitoring	Improved monitoring can lead to reduced sprays through "spray when necessary" rather than "calendar" timing. Tomatoes serve as a reservoir for some natural enemies that move from tomato fields to other plantings such as cotton, melons, and beans; these insects are factors in helping to control pests in other crops. *In processing tomatoes,* begin sampling fruit when it has reached 1 inch or more in diameter. Treatment is not necessary prior to this size as the damaged fruit will fall from the plant and little yield loss will occur. *In fresh market tomatoes,* begin sampling when fruit appears. Pheromone traps are useful for determining when major flights occur, but not for predicting damage. A 5-minute timed search is useful in determining the need for treatment. On average, if one or more larvae or egg masses are found in 5 minutes, treatments may be justified.	
Organophosphates	Benefits	Excellent control of targeted insects.
	Drawbacks	Easily transported in water. Somewhat hard on beneficials though not to the same degree as pyrethroids.
Pyrethroids	**Benefits**	Excellent control of targeted insects. Not easily transported in water since they attach easily to soil particles
	Drawbacks	Resistance occurs quicker in pyrethroids than other classes of chemicals. Hard on beneficials leading to secondary pest outbreaks, especially aphids. Highly toxic to fish in solution. Can be transported off-site with sediment during rainfall or irrigation events.
Alternate Materials	Some alternate materials are now available for treatment of worms or aphids in tomatoes. Please consult your PCA for more information.	
In-Season Spray BMPs		
Insecticides & Herbicides		

<table>
<tr><td>Drift</td><td colspan="3">The ability to detect products in streams and rivers at parts per trillion levels leaves little room for error.
To prevent problems, equipment operators must take extra care when spraying near sensitive areas and bodies of water.
Shutoff equipment near windrow ends.
Avoid applying when wind is blowing toward waterways or other sensitive areas.
Leave buffer zone to protect sensitive areas.
Use of larger droplet sizes.
Use of drift retardant chemicals in the spray mix. Although these are effective in reducing the number of drift-prone droplets, in most cases it is more effective to select the proper size and type of nozzles and operate sprayers at low pressure to produce the desired drop size, rather than attempt to increase droplet size with drift retardant chemicals.</td></tr>
<tr><td colspan="4">Tomato Field Practice BMPs</td></tr>
<tr><td>Cultural Practices</td><td colspan="3">Disk harvested fields as soon as possible to prevent any pinworm problems and also to prevent tomato fields from being a source for the buildup of pests (lygus, whitefly) which may damage other crops</td></tr>
<tr><td rowspan="7">Irrigation Runoff Management</td><td rowspan="2">Catchment basins</td><td>Benefits</td><td>Catchment basins with tailwater return systems can alleviate excess runoff preventing runoff from moving into surface waters.
Water savings</td></tr>
<tr><td>Drawbacks</td><td>Unlined catchment basins can contribute to downward movement of pesticides towards groundwater, so design is very crucial.</td></tr>
<tr><td>Improved soil monitoring</td><td colspan="2">Timing of irrigations is important so that moisture levels are not too high when irrigations occur, allowing for increased infiltration.</td></tr>
<tr><td rowspan="3">PAM Applications</td><td colspan="2">PAM is a polymer compound injected or fed into irrigation water at the head of a field supply ditch or discharge point.
Applications rates range from 5-8 pounds per acre with the material typically metered into the head ditch with a gandy-type applicator</td></tr>
<tr><td>Benefits</td><td>In newly formed furrows, soil does not move down the row or erode when irrigation water is treated with PAM.
Suspended soil particles drop out of irrigation water containing PAM.
After an irrigation containing PAM, furrow erosion and transport of sediment is greatly reduced in subsequent irrigations.
Erosion reductions of 95% have been documented in numerous field trials and commercial applications in the San Joaquin Valley.</td></tr>
<tr><td>Drawbacks</td><td>Additional cost (especially with more frequent irrigations of tomatoes).
Is not effective in preventing solubilized pesticides from moving off-site.</td></tr>
<tr><td>Sprinklers</td><td colspan="2">Amount of water can be controlled and therefore runoff is more easily controlled.</td></tr>
</table>

Vegetative Buffers	Areas or strips of land surrounding a field that are maintained in permanent vegetation. To effectively trap pesticides, buffers must slow water runoff and increase infiltration so that pesticides can be trapped and degraded in buffer soil and vegetation. Vegetative buffers are a tool to further improve water quality and provide additional benefits such as wildlife habitat and stream bank protection. For best success, they should be used in conjunction with other mitigation practices.	
	Benefits	Can be used to manage soil, water, nutrients and pesticides while minimizing environmental impacts. Effective in trapping eroded sediment, reducing runoff of pesticides that are adsorbed to soil particles. Note: some pesticides (e.g. OPs) are highly water soluble and don't adsorb to soil particles as readily as others (e.g. pyrethroids).
	Drawbacks	California-based research is limited on the potential for filter strips and grassed waterways to reduce OP pesticide loading, although the practices have been shown to be effective in other regions of the U.S. Uncertainties of buffers include: appropriate dimensions for volume of water flow; appropriate plant species and plant density for the soil types and rainfall zones; considerations for various locations; slope and channel dimensions for grassed waterways; and dimensions for constructed wetlands. Can require growers to set aside productive acreage.
Vegetative Filter Strips	Areas of grass or other permanent vegetation used to reduce sediment, organics, nutrients, pesticides and other contaminants in runoff to maintain or improve water quality. Vegetative filter strips are located between crop fields and water bodies, i.e. grassed roadways. Plant material captures rainfall and retains nutrients. Roadways can be grassed or sod planted, as can sprayer mixing pads and wellheads. Depending upon the site, a full border around a field may not be necessary for mitigating impacts to surface water. Filter strips could be planted at tail ends of fields or in other critical zones.	
	Benefits	Slows runoff allowing sediment to drop out of suspension. Traps sediment with adsorbed pesticide residues. Increases water infiltration into the soil profile. Catches some pesticide drift, preventing it from reaching the soil.
	Drawbacks	If water runoff is channeled, a grass strip may not effectively trap the adsorbed pesticides.
Grassed Waterways	Natural or constructed channels planted in permanent vegetation and located in an area where runoff concentrates. Constructed waterways can be graded to carry surface water at a non-erosive velocity to a stable outlet. Waterways are most effective in trapping sediment and dissolved chemicals when designed to spread concentrated water flow evenly cross a vegetative filter adjacent to waterways.	
	Benefits	Helps slow the flow of water to a non-erosive level. Provides a means of trapping sediment, nutrients, and pesticides while preventing gully erosion. Provides habitat and cover for wildlife.
	Drawbacks	Overgrown channels causing waterway breaching and flooding can restrict storm flows. Due to the concentrated flow that normally occurs in waterways, sediment trapping and water infiltration can be minimal with large runoff events, but substantial with smaller events.
Filter Ditches	Areas filled with activated charcoal, peat, or other filtering agents at locations where water leaves the ranch. These would be replaced periodically and would filter pesticides before the soil solution reaches surface water.	

	Benefits	Further research is needed in California but other areas of the US have shown effective reduction of pesticide residue.
	Drawbacks	High cost due to materials and increased maintenance needed.
Riparian Buffers	Trees and shrubs planted adjacent to streams, lakes, ponds and wetlands. Forest buffers are frequently combined with an understory of perennial grass buffers.	
	Benefits	Helps lower water temperatures by shading the water body. Protects stream banks and slows out-of-bank flood flows. Deep tree roots may intercept nitrate entering streams in shallow subsurface flow and provide soil carbon for microbial energy. Microbes can denitrify nitrate and degrade pesticides. Woody vegetation provides food and cover for wildlife. Contributes energy sources to aquatic communities.
	Drawbacks	If water runoff is channeled, riparian buffers may not effectively trap pesticides.
Constructed Wetlands	Wetlands constructed at tile outlets or as part of riparian buffer systems for degrading pesticides and denitrifying nitrates.	
	Benefits	Provides confined area for breakdown of pesticides in water.
	Drawbacks	Land needed for constructed wetlands is not readily available in high production areas. Available land can be costly.
Hedgerows	Fences of shrubs or trees in, across, or around a field. Hedgerows can include an understory composed of perennial native grasses and forbs, a shrub midstory composed of California native species and occasionally a discontinuous overstory of valley and foothill trees.	
	Benefits	May reduce erosion by having perennial vegetation on a portion of the field. If runoff flows across the hedgerow in sheet flow, sediment can be trapped, reducing the amount of sediment and sediment-borne pesticides from entering surface waters. Can attract beneficial insects and provide competition against invasive weeds. Windbreaks and hedgerows can provide drift mitigation, potentially reducing off-site movement of pesticides. Because many of the native species used in hedgerows have deep roots that hold the soil and increase water permeability, there may be a reduction in water runoff and off site movement of sediment. This could reduce runoff of pesticides in the dissolved and sediment-borne phases of field runoff. However, no studies have quantitatively measured the reductions in OP pesticide runoff.

	Drawbacks	Certain plant species may attract pests that can attack the crop or neighboring crops. Careful consideration must be given to the species of vegetation selected and the types of insects that may be attracted. Plant species can provide habitat and attract endangered species. Safe Harbor Agreements are available to protect growers where a practice is implemented that could attract endangered species to their farms, a factor that should be evaluated and addressed before establishing hedgerows. Some species can grow 10-15 feet wide, so space must be allowed for equipment to pass.
Stewardship BMPs		
Mixing / Loading/Cleanup		
Concrete or Asphalt Pad	Use concrete or asphalt pad that drains to a central sump	
Proximity of mixing/loading area	Take precautions to insure that the minimum distance between any mixing/loading area and any ditches, canals or streams that feed into nearby rivers is at least 100 feet. Take precautions to insure that the minimum distance between any mixing/loading area and pump is at least 100 feet.	
Equipment	Check equipment for cracked / broken hoses, valves, etc. Calibrate prior to each application. Use spray nozzles with large droplet size to minimize drift.	
Tank filling	Fill tank to 1/3 to ½ full prior to the addition of chemicals. Use air gap to prevent tank overfilling. Use backflow valve on the fill tube.	
Personnel	Person(s) always present during mixing/loading operations. Person(s) trained to take corrective action when necessary.	
Storage Areas	Have spill containment capability to protect from runoff into any nearby surface waters. Use impermeable surface (coated or sealed concrete) with curbs for floors.	
Cleanup	Mix rinseate with water and reapply to field. Clean equipment on appropriate pad at least 300 feet from surface waters. Triple rinse empty containers and dispose of in landfill or recycling area.	
Nutrient/Fertilizer Application BMPs		
Soil, Tissue and Water Testing	Base N fertilizer amount and timing on crop needs and production goals. Before applying N early in the growth cycle, assess the amount of nitrate already present by soil (or soil solution) sampling and analysis. Use plant tissue sampling for mid- and late season fertilizer decisions. Measure nitrate levels in the irrigation water and adjust N fertilizer rate accordingly.	

Application Timing	Determine the amount of nitrate already present in the soil. Apply N, P and K at a rate consistent with the crop nutrient requirements. Split applications of N fertilizer. Do not apply excessive single amounts of fertilizer N during the rainy season. For fertilizer application during fall, use only low N-containing materials such as N:P2O5:K2O equal to 1:3:3. Higher N materials may be appropriate if a crop is to be planted soon.	
Fertilizer Placement	Place N fertilizer materials where maximum plant uptake will occur.	
Irrigation	Adopt sprinkler irrigation. If fields are more than 1000 feet long, consider cutting the run length in half with a corresponding decrease in set time. Use high flow rates initially to get water down the field and then cut back to finish off the irrigation. Avoid doing the opposite. Collect surface water runoff for recirculation or reuse in other fields.	
Application Practices	Clean-up fertilizer spills promptly. Shut off fertilizer applicators during turns and use check valves when possible. Maintain proper calibration of fertilizer application equipment. Whenever injecting fertilizer into irrigation water, ensure backflow does not occur. Rinse water from fertilizer tanks should be evenly spread throughout a field. Fertilizer tanks and equipment should be cleaned by rinsing in the field or at a properly designed wash facility. Rinse water and/or sludge should be evenly spread across a field using good agronomic practices. When equipment is parked, use care to prevent material from leaking into storage area. If equipment is known to be in disrepair, completely remove fertilizer material before parking equipment. When transferring fertilizer into on-farm storage or into a fertilizer applicator, take care not to allow materials to accumulate on the soil. Good housekeeping practices should be implemented to prevent contamination of groundwater and/or surface water.	
Sediment Control BMPs		
Water and Sediment Control Basins	Constructed earth embankments or a combination ridge and channel. Constructed across the slope and minor watercourses to form a sediment trap and water detention basin.	
	Benefits	Trap sediment and pesticides adsorbed to soil particles. Reduce and manage onsite and downstream runoff. Divert the flow of dissolved substances such as nutrients and pesticides. Improve the farmability of sloping land, reduce water course and gully erosion. Improve downstream water quality.
	Drawbacks	Basins are not viable for many orchard areas in California, primarily because considerable land acreage would be required to manage the volumes of water typically produced in rainfall events, especially in the Sacramento Valley.
PAM Applications	PAM is a polymer compound injected or fed into irrigation water at the head of a field supply ditch or discharge point. Applications rates range from 5-8 pounds per acre with the material typically metered into the head ditch with a gandy-type applicator	

	Benefits	In newly formed furrows, soil does not move down the row or erode when irrigation water is treated with PAM. Suspended soil particles drop out of irrigation water containing PAM. After an irrigation containing PAM, furrow erosion and transport of sediment is greatly reduced in subsequent irrigations. Erosion reductions of 95% have been documented in numerous field trials and commercial applications in the San Joaquin Valley.
	Drawbacks	Additional cost Is not effective in preventing solubilized pesticides from moving off-site.
Tailwater Return Systems	**Benefits**	Use of tailwater can offer substantial savings in irrigation power consumption if the water supply is groundwater. A tailwater recovery system increases yields because of higher irrigation efficiencies. A tailwater recovery system will not save all the tailwater, but it can increase irrigation efficiency by 25 to 30 percent.
	Drawbacks	The loss of the area required for a reuse pit and periodic maintenance of the pump, storage and return facilities.
Compaction / Wheel Rutting	Wheel ruts formed by equipment passing through wet fields can create channels for water and sediment to runoff from orchards. Where possible, minimize creation of wheel ruts with dormant orchard sprayers, brush shredders or other equipment when orchard floor is saturated.	
Drainage System Management	Filtering runoff water through vegetation allowed to grow in drainage ditches may help mitigate offsite movement of sediment as well as pesticides dissolved in storm runoff.	
Avoiding Channelization of Streams and Creeks	Allowing streams to naturally flow and meander can increase runoff retention and infiltration. A modified or channeled stream could also be restored to a more natural state by re-establishment of the riparian vegetation, which also provides stream bank protection.	
Berms at Low Ends of Fields (sandy soils, low slope)	Raised berms at low ends of fields can trap sediment and adsorbed pesticides reducing runoff of dissolved substances in fields with low slopes and sandy soil types. Berms hold back water, increasing runoff retention and allowing infiltration.	
Aeration	Use of specialized tillage equipment to break crusts and aerate soils with the intent of increasing water penetration and retention, thus reducing runoff. Aeration improves the soil profile with minimal disruption to the floor if completed during dormant season. Aeration may reduce OP pesticide runoff although no studies have been conducted.	
Improving soil texture (tilth)	Practices such as gypsum (or sulfur in higher lime soils) and humic acid applications or actions of earthworms have potential to increase water penetration and reduce runoff in compacted soils or where an impermeable soil layer exists. However, no studies have been conducted to show efficacy in reducing OP pesticide runoff with these approaches.	
	Benefits	Increased water penetration resulting in less runoff and increased recharging of the soil profile. Less water runoff means less potential for pesticides to be transported off-site.
	Drawbacks	Results vary with soil type and, under some conditions, compaction could increase. Improved soil permeability may increase movement of nitrate and other chemicals into groundwater. The balance of benefits versus disadvantages is not clear at this time and more research is needed.

Reference:

Integrated Pest Management for Tomatoes 4th edition: University of California Statewide IPM Project. 1998. 120pp.

http://ipm.ucdavis.edu/PMG/selectnewpest.tomatoes.html

Mixing and Loading Crop Sprayers, Tips and Techniques, Protecting Water Quality: Coalition for Urban/Rural Environmental Stewardship (http://www.curesworks.org)

Field and Row Crop Sprayers, Tips and Techniques, Protecting Water Quality: Coalition for Urban/Rural Environmental Stewardship (http://www.curesworks.org)

Crop: Walnuts	
Compilation of Best Management Practices to Protect Surface Water from Farm Runoff	
Pesticide Application BMPs	
Dormant Season Sprays	
Monitoring	Improved monitoring can lead to reduced sprays through “spray when necessary” rather than “calendar” timing. Base treatment decisions on monitoring of the field.
Dormant Diazinon and Oil Spray	Diazinon combined with dormant oil during the dormant season. Diazinon applications are frequently alternated with non-OP pesticides to prevent resistance from developing to either diazinon or non-OP pesticides. Information is being developed on earlier timing of winter OP applications when less rainfall is likely or when the rainfall is more likely to be absorbed into the soil rather than runoff. Reduced rates: additional data is needed to demonstrate effects at varying pest densities.
No Dormant Treatment or Dormant Oil Only Treatment	Dormant insecticide spray is not applied or an oil only treatment is made. Skipping dormant insecticide sprays has been successful when pest pressure is low or non-existent.
Alternate Year Dormant OP Pesticide With Yearly Oil Spray	Use dormant OP every other year but use dormant oil on an annual basis. In years with no dormant OP used the following may be necessary: - Additional in-season treatments. - Additional in-season treatments for mites are possible following in-season applications of carbaryl, esfenvalerate and permethrin.

Dormant Spray (Non-OP Pesticides) and Oil	Pyrethroids (permethrin and esfenvalerate) and carbamates (carbaryl) in the delayed-dormant or dormant season. Residues of the pyrethroid insecticides permethrin and esfenvalerate persist on bark and may impact naturally occurring predator mites for extended periods of time after dormant season and in-season applications. Mite outbreaks caused by use of pyrethroids may require additional miticide treatments over and above those normally applied. In general, insects become resistant to pyrethroids more rapidly than other classes of pesticides. Some registered products are not widely used in the dormant season because of possible effects on non-target organisms or because of label restrictions. For example, carbaryl cannot be used in orchards where honeybees are present and endosulfan use is restricted near water or wetlands. Non-OP pesticides can affect non-target organisms in water and the potential for offsite movement from runoff has not been well studied. If a non-OP pesticide is applied as a dormant spray, precautions such as on-site practices (following sections) should be taken to prevent movement into surface waters. Laboratory exposures indicate that fish and invertebrates are particularly sensitive to pyrethroids. Pyrethroid persistence may mean that they will be transported off site. If so, they may be bioavailable to fish in water or to invertebrates in sediment. Sediment toxicity may result after pyrethroids are transported into water bodies.
Pheromone Mating Disruption for Codling Moth	Mating disruption relies on releasing pheromones through dispensers distributed throughout an orchard or applied as a spray. Codling moth control can be achieved with insecticide sprays or with pheromone dispensers to disrupt mating. The use of mating disruption to control codling moth in walnut orchards is effective, but only economical for small walnut trees (less than 20 feet tall) with low populations of codling moth. Mating disruption is most successful in large (more than 10 acres) uniform orchards on flat ground, with moderate canopy height (30 feet or less) and relatively low to moderate codling moth populations. It is less effective in orchards with tall trees and/or susceptible varieties (e.g., Ashley, Payne, Serr, Vina) with a large codling moth population history or a prior history of economically significant codling moth damage. In these situations, make the transition to a mating disruption program with a combination program first: begin by using chemical control in addition to mating disruption for the first year. Pheromone mating disruption cannot be considered a stand-alone system. It is selective for the target pest so monitoring for other orchard pests as well as codling moth is necessary.
Dormant Season Spray BMPs	

<table>
<tr><td colspan="2">Restrict dormant spray applications (except oil alone) to ground applications only.
Do not apply within 100 feet upslope of any sensitive aquatic site that may drain into a river or tributary unless runoff is contain or diverted from the sensitive aquatic site. Waters that are contained or diverted must be held for 72 hours before they can be released into a sensitive aquatic site.
Maintain a vegetative buffer strip a minimum of 10 feet wide from the edge of the field to sensitive aquatic sites.
Do not apply dormant sprays (except oil alone) when soil moisture is at field capacity and a storm is predicted in the next 48 hours.
Do not apply dormant sprays (except oil alone) when surface runoff to sensitive aquatic sites from a rain event could occur within 48 hours after the application.
Make dormant applications only when insect-scouting information indicates pest populations have reached damaging levels. (See University of California Integrated Pest Management Guidelines for walnuts.)
Apply only when wind speed is 3-10 mph at the application site as measured by an anemometer outside of the orchard on the upwind side.
When air currents are moving (>3 mph) toward sensitive aquatic sites, commence applications on side nearest the site and proceed spraying away from the water body.
Spray last three rows upwind of bodies of water using nozzles on one side only, with spray directed away from sensitive aquatic sites.
Reduce the maximum rate of application and the number of applications.
Alternate the dormant use of organophosphorous and pyrethroid insecticides with other environmentally reduced risk pesticides or make application in season according to University of California Integrated Pest Management recommendations.</td></tr>
<tr><td colspan="2">Dormant Orchard Field Practice BMPs</td></tr>
<tr><td>Sanitation Practices</td><td>For Navel Orangeworm:
- Reduce overwintering populations by flailing or burning all crop waste containing sound nuts. This includes removing all mummy nuts found in the trees during the dormant period, all windfall and huller waste materials found in the field, and all waste materials cleaned up from bins, hulling and drying equipment, and buildings after harvest and dehydration.</td></tr>
<tr><td>Orchard Floor Vegetation During Dormant Season</td><td>Seeded or resident vegetation growing on orchard floors that is later mowed or disked.
Resident Vegetation - existing, unplanted mixture of annual or perennial weeds, crop species and/or native grasses and forbs which has adapted to management methods used in the orchard.
Seeded vegetation - cover crops that include many types of cultivated species including legumes (bell beans, peas, clover, medics and vetches) and grasses such as cereal grains, turf grasses and sudan grass.</td></tr>
</table>

	Resident or Seeded Vegetation (continued)	**Benefits**	Orchard floor vegetation can reduce dormant spray pesticide runoff to surface waters in several ways: - Can be easily encouraged to grow in the fall or early winter by a post harvest irrigation or early rains and requires little to no management to establish. - Reduction in runoff volume through increased water infiltration. - Reduction in sheet erosion caused by rainfall impact on bare ground. - Decrease in pesticide mass carried by sediment. - Shorter pesticide persistence (faster breakdown) on vegetation than soil. - Adsorption of pesticides to plant surfaces. - Anchors soil during winter rains preventing soil, nutrient and pesticide runoff. - Allows pesticides to break down and be filtered onsite. Adds organic material to the soil. Accelerates the biodegradation of pesticides in soil. Can reduce plant parasitic nematodes by antagonism. Legume cover crops fix atmospheric nitrogen and release it to the orchard crop during the growing season. Improves water infiltration, soil aeration and soil texture. Improves soil fertility. Assists in weed control (seeded covers). Improves orchard access during wet weather. Cover crops provide nectar sources, pollen and prey for beneficial predators.
		Drawbacks	Difficult to manage if noxious weeds are present and requires mechanical or herbicide control in late winter or early spring if overgrown. Increased cover and feed for gophers, ground squirrels and mice (also higher populations from increased habitat and reduced predation). Increased humidity can potentially create conditions for fungal diseases. Potentially increased nematode populations with summer-grown cover crop. Higher water use with perennial cover crops. Sprinklers can be blocked by climbing vetches. Blooming cover crops can compete with tree crops for pollinator insects if not mowed. Increased danger of frost damage. A tall, dense cover crop can reduce nighttime temperatures by up to 5 or 6 degrees, increasing the potential for frost damage. However, orchards with closely mowed cover crops and moist soil may be only about 1 degree colder than bare soil. Alternate row cover cropping can reduce the difference even more. Mowing before frost reduces the risk of frost damage.

Cover Crop Management	**Cover and Green Manure Crop**	Plants are disked to incorporate organic material and improve soil fertility and tilth. Disking (or mowing) is generally done when plants are in full-bloom to post-bloom stage, depending on frost potential and soil moisture conditions.
	Mowed Cover Crop	Managed by mowing to maintain at least 60% ground cover where erosion is possible. Mowing to 3-4 inches prior to frost can reduce cold temperature damage potential. Mowing intervals can often allow adequate seed production for following season re-growth. Mowed cover crops reduce dust during harvest operations and improve water infiltration rates.
	Disked Cover Crop	Plants typically disked at full-bloom to post-bloom stage, depending on condition of the target crop, weather and soil moisture conditions. Maintain at least 60% ground cover where erosion is possible. Mowing to 3-4 inches prior to frost can reduce potential for cold temperature damage.
Vegetative Buffers	Areas or strips of land surrounding an orchard that are maintained in permanent vegetation. To effectively trap pesticides, buffers must slow water runoff and increase infiltration so that pesticides can be trapped and degraded in buffer soil and vegetation. Vegetative buffers are a tool to further improve water quality and provide additional benefits such as wildlife habitat and stream bank protection. For best success, they should be used in conjunction with other mitigation practices.	
	Benefits	Can be used to manage soil, water, nutrients and pesticides while minimizing environmental impacts. Effective in trapping eroded sediment, reducing runoff of pesticides that are adsorbed to soil particles. Note: some pesticides (e.g. OPs) are highly water soluble and don't adsorb to soil particles as readily as others (e.g. pyrethroids).
	Drawbacks	California-based research is limited on the potential for orchard filter strips and grassed waterways to reduce OP pesticide loading, although the practices have been shown to be effective in other regions of the U.S. Uncertainties of buffers include: appropriate dimensions for volume of water flow; appropriate plant species and plant density for the soil types and rainfall zones; considerations for various locations; slope and channel dimensions for grassed waterways; and dimensions for constructed wetlands. Can require growers to set aside productive acreage.
Vegetative Filter Strips	Areas of grass or other permanent vegetation used to reduce sediment, organics, nutrients, pesticides and other contaminants in runoff to maintain or improve water quality. Vegetative filter strips are located between crop fields and water bodies, i.e. grassed roadways. Plant material captures rainfall and retains nutrients. Roadways can be grassed or sod planted, as can sprayer mixing pads and wellheads. Depending upon the site, a full border around an orchard may not be necessary for mitigating impacts to surface water. Filter strips could be planted at low ends of fields or in other critical zones.	
	Benefits	Slows runoff allowing sediment to drop out of suspension. Traps sediment with adsorbed pesticide residues. Increases water infiltration into the soil profile. Catches some pesticide drift, preventing it from reaching the soil.

	Drawbacks	If water runoff is channeled, a grass strip may not effectively trap the adsorbed pesticides.
Vegetative Barriers	Narrow, permanent strips of stiff stemmed, erect, dense, perennial vegetation established in parallel rows and perpendicular to the dominant slope of the field.	
	Benefits	Effective in dispersing concentrated flow, thus increasing sediment trapping and water infiltration.
	Drawbacks	If water runoff is channeled, a vegetative barrier may not effectively trap the adsorbed pesticides.
Grassed Waterways	Natural or constructed channels planted in permanent vegetation and located in an area where runoff concentrates. Constructed waterways can be graded to carry surface water at a non-erosive velocity to a stable outlet. Waterways are most effective in trapping sediment and dissolved chemicals when designed to spread concentrated water flow evenly cross a vegetative filter adjacent to waterways.	
	Benefits	Helps slow the flow of water to a non-erosive level. Provides a means of trapping sediment, nutrients, and pesticides while preventing gully erosion. Provides habitat and cover for wildlife.
	Drawbacks	Overgrown channels causing waterway breaching and flooding can restrict storm flows. Due to the concentrated flow that normally occurs in waterways, sediment trapping and water infiltration can be minimal with large runoff events, but substantial with smaller events.
Riparian Buffers	Trees and shrubs planted adjacent to streams, lakes, ponds and wetlands. Forest buffers are frequently combined with an understory of perennial grass buffers.	
	Benefits	Helps lower water temperatures by shading the water body. Protects stream banks and slows out-of-bank flood flows. Deep tree roots may intercept nitrate entering streams in shallow subsurface flow and provide soil carbon for microbial energy. Microbes can denitrify nitrate and degrade pesticides. Woody vegetation provides food and cover for wildlife. Contributes energy sources to aquatic communities.
	Drawbacks	If water runoff is channeled, riparian buffers may not effectively trap pesticides.
Constructed Wetlands	Wetlands constructed at tile outlets or as part of riparian buffer systems for degrading pesticides and denitrifying nitrates.	
	Benefits	Provides confined area for breakdown of pesticides in water.
	Drawbacks	Land needed for constructed wetlands is not readily available in high production areas. Available land can be costly.
Hedgerows	Fences of shrubs or trees in, across, or around a field. Hedgerows can include an understory composed of perennial native grasses and forbs, a shrub midstory composed of California native species and occasionally a discontinuous overstory of valley and foothill trees.	

	Benefits	May reduce erosion by having perennial vegetation on a portion of the field. If runoff flows across the hedgerow in sheet flow, sediment can be trapped, reducing the amount of sediment and sediment-borne pesticides from entering surface waters. Can attract beneficial insects and provide competition against invasive weeds. Windbreaks and hedgerows can provide drift mitigation, potentially reducing off-site movement of pesticides. Because many of the native species used in hedgerows have deep roots that hold the soil and increase water permeability, there may be a reduction in water runoff and off site movement of sediment. This could reduce runoff of pesticides in the dissolved and sediment-borne phases of field runoff. However, no studies have quantitatively measured the reductions in OP pesticide runoff.
	Drawbacks	Certain plant species may attract pests that can attack the crop or neighboring crops. Careful consideration must be given to the species of vegetation selected and the types of insects that may be attracted. Plant species can provide habitat and attract endangered species. Safe Harbor Agreements are available to protect growers where a practice is implemented that could attract endangered species to their farms, a factor that should be evaluated and addressed before establishing hedgerows. Some species can grow 10-15 feet wide, so space must be allowed for equipment to pass.
Reducing or Eliminating the Herbicide-Sprayed Berm	Berm areas of orchards sprayed with herbicides represent a bare conduit for runoff of rainfall or irrigation water. By allowing vegetation to grow and reducing the berm width or seasonal spraying of the berm, runoff potential from an orchard could be reduced. Options - Reduce strip spray widths by 25%. - Apply herbicide in January/February after sprouted grass covers the berm. - Spray a 5-foot square block around trees to keep the trunk area clean but leave vegetation on the remainder of the row berm. - Stop spraying herbicides at the next-to-the-last tree in each row, leaving a vegetative barrier surrounding the orchard. - Eliminate use of pre-emergence herbicides.	
	Benefits	Cost Savings Reduction in runoff volume through increased soil infiltration. Decrease in soil erosion and movement of pesticides with soil borne runoff. Shorter pesticide persistence on vegetation than soil and better absorption on plant surfaces (faster degradation on plant matter). An orchard floor that is completely vegetated versus 25% bare soil has greater area for these mechanisms to function.
	Drawbacks	Vegetation on berms can be difficult to manage in orchards. Vegetation control can be difficult if excessive growth occurs before herbicide is applied.
In-Season Spray BMPs		
Insecticides & Herbicides		

Monitoring	Codling Moth - In orchards treated with organophosphate or carbamate insecticides, time all treatments to kill larvae as they emerge from eggs. (If insect growth regulators are used, apply treatments before egg laying or egg hatch, depending on the material used.) Use pheromone traps, degree-days (DD), and sunset temperatures to monitor codling moth activity and determine when egg hatch occurs. Aphid Monitor beginning in early March for Dusty-veined aphid and in May both Walnut aphid. Mites - Monitor for mites beginning in June.
Drift	The ability to detect products in streams and rivers at parts per trillion levels leaves little room for error. To prevent problems, equipment operators must take extra care when spraying near sensitive areas and bodies of water. Shutoff equipment when making row turns. Avoid spraying when wind is blowing toward waterways or other sensitive areas. Leave buffer zone to protect sensitive areas.
Managing Irrigation Runoff	Tailwater return systems can alleviate excess runoff preventing runoff from moving into surface waters. Use vegetative barriers (see dormant orchard field practices) to filter runoff prior to leaving site. Use of drip irrigation, especially buried drip has reduced or eliminated irrigation-induced runoff.
Cultural Controls	For Navel Orangeworm: - Reduce sources of population increase during the season by effectively controlling both walnut blight and codling moth. - Harvest when first possible. Use of ethephon to advance husk splitting is advantageous, particularly during heavy worm populations or prolonged dry falls. - Dry nuts immediately and either fumigate on the farm if stored or ship immediately where fumigation will be performed. - Chemical treatments are only partially effective (provide about 50% control) against navel orangeworm infestations. The key to control of this pest is orchard sanitation, control of codling moth and walnut blight, and harvesting at the earliest possible date. In many orchards, proper use of these practices should eliminate need for insecticide treatment. Mites - Orchard management practices can reduce mite problems. Minimize dust by oiling orchard roads and maintaining a ground cover. Well-irrigated, vigorous trees are less troubled by mite infestations. - Keep orchard clean of Field Bindweed. Mites will often colonize bindweed 10 to 14 days before moving into trees. - Choose selective pesticides when controlling other pests and try to avoid pyrethroids, organophosphates, and carbamates.
Stewardship BMPs	
Mixing / Loading/Cleanup	
Concrete or Asphalt Pad	Use concrete or asphalt pad that drains to a central sump

Proximity of mixing/loading area	Take precautions to insure that the minimum distance between any mixing/loading area and any ditches, canals or streams that feed into nearby rivers is at least 100 feet. Take precautions to insure that the minimum distance between any mixing/loading area and pump is at least 100 feet.
Equipment	Check equipment for cracked / broken hoses, valves, etc. Calibrate prior to each application. Use spray nozzles adjusted for crop canopy. Use nozzles with large droplet size to minimize drift.
Tank filling	Fill tank to 1/3 to ½ full prior to the addition of chemicals. Use air gap to prevent tank overfilling. Use backflow valve on the fill tube.
Personnel	Person(s) always present during mixing/loading operations. Person(s) trained to take corrective action when necessary.
Storage Areas	Have spill containment capability to protect from runoff into any nearby surface waters. Use impermeable surface (coated or sealed concrete) with curbs for floors.
Cleanup	Mix rinseate with water and reapply to field. Clean equipment on appropriate pad at least 300 feet from surface waters. Triple rinse empty containers and dispose of in landfill or recycling area.
Nutrient/Fertilizer Application BMPs	
Soil, Tissue and Water Testing	Base N fertilizer amount and timing on crop needs and production goals. Before applying N early in the growth cycle, assess the amount of nitrate already present by soil (or soil solution) sampling and analysis. Use plant tissue sampling for mid- and late season fertilizer decisions. Measure nitrate levels in the irrigation water and adjust N fertilizer rate accordingly.
Application Timing	When applying manure shortly before a crop is planted, determine the nutrient content of the manure and the amount of nitrate already present in the soil. Apply manure at a rate consistent with the crop nutrient requirements. Split applications of N fertilizer. No not apply excessive single amounts of fertilizer N during the rainy season. For fertilizer application during fall tillage, use only low N-containing materials such as N:P2O5:K2O equal to 1:3:3. Higher N materials may be appropriate if a crop is to be planted soon.
Fertilizer Placement	Place N fertilizer materials where maximum plant uptake will occur. Incorporate N fertilizer into the crop bed by either placing fertilizer on or near the seed row and watering it in, knifing fertilizer into the bed or broadcasting fertilizer then listing it up into the bed. Incorporate manures and other organic amendments into soil with consideration of the timing of conversion of manure N to other forms.

Irrigation		Adopt surge irrigation. Improve irrigation uniformity by turning irrigation water on and off as it flows down the furrow. If fields are more than 1000 feet long, consider cutting the furrow run length in half with a corresponding decrease in set time. Use high flow rates initially to get water down the field and then cut back to finish off the irrigation. Avoid doing the opposite. Use practices that increase uniformity among furrows (e.g. torpedoes, extra tractor trips, etc.) Collect surface water runoff for recirculation or reuse in other fields.
Application Practices		Clean-up fertilizer spills promptly. Shut off fertilizer applicators during turns and use check valves when possible. Maintain proper calibration of fertilizer application equipment. Whenever injecting fertilizer into irrigation water, ensure backflow does not occur. Rinse water from fertilizer tanks should be evenly spread throughout a field. Fertilizer tanks and equipment should be cleaned by rinsing in the field or at a properly designed wash facility. Rinse water and/or sludge should be evenly spread across a field using good agronomic practices. When equipment is parked, use care to prevent material from leaking into storage area. If equipment is known to be in disrepair, completely remove fertilizer material before parking equipment. When transferring fertilizer into on-farm storage or into a fertilizer applicator, take care not to allow materials to accumulate on the soil. Good housekeeping practices should be implemented to prevent contamination of groundwater and/or surface water.
Cover Crops		If conditions permit, grow a cover crop to use excess nitrogen and prevent leaching rather than leaving fields fallow during the rainy season.
Sediment Control BMPs		
Water and Sediment Control Basins		Constructed earth embankments or a combination ridge and channel. Constructed across the slope and minor watercourses to form a sediment trap and water detention basin.
	Benefits	Trap sediment and pesticides adsorbed to soil particles. Reduce and manage onsite and downstream runoff. Divert the flow of dissolved substances such as nutrients and pesticides. Improve the farmability of sloping land, reduce water course and gully erosion. Improve downstream water quality.
	Drawbacks	Basins are not viable for many orchard areas in California, primarily because considerable land acreage would be required to manage the volumes of water typically produced in rainfall events, especially in the Sacramento Valley.
PAM Applications		PAM is a polymer compound injected or fed into irrigation water at the head of a field supply ditch or discharge point. Applications rates range from 5-8 pounds per acre with the material typically metered into the head ditch with a gandy-type applicator

	Benefits	In newly formed furrows, soil does not move down the row or erode when irrigation water is treated with PAM. Suspended soil particles drop out of irrigation water containing PAM. After an irrigation containing PAM, furrow erosion and transport of sediment is greatly reduced in subsequent irrigations. Erosion reductions of 95% have been documented in numerous field trials and commercial applications in the San Joaquin Valley.
	Drawbacks	Additional cost
Tailwater Return Systems	**Benefits**	Use of tailwater can offer substantial savings in irrigation power consumption if the water supply is groundwater. A tailwater recovery system increases yields because of higher irrigation efficiencies. A tailwater recovery system will not save all the tailwater, but it can increase irrigation efficiency by 25 to 30 percent.
	Drawbacks	The loss of the area required for a reuse pit and periodic maintenance of the pump, storage and return facilities.
Compaction / Wheel Rutting	Wheel ruts formed by equipment passing through wet fields can create channels for water and sediment to runoff from orchards. Where possible, minimize creation of wheel ruts with dormant orchard sprayers, brush shredders or other equipment when orchard floor is saturated.	
Drainage System Management	Filtering runoff water through vegetation allowed to grow in drainage ditches may help mitigate offsite movement of sediment as well as pesticides dissolved in storm runoff.	
Avoiding Channelization of Streams and Creeks	Allowing streams to naturally flow and meander can increase runoff retention and infiltration. A modified or channeled stream could also be restored to a more natural state by re-establishment of the riparian vegetation, which also provides stream bank protection.	
Berms at Low Ends of Fields (sandy soils, low slope)	Raised berms at low ends of fields can trap sediment and adsorbed pesticides reducing runoff of dissolved substances in fields with low slopes and sandy soil types. Berms hold back water, increasing runoff retention and allowing infiltration.	
Planting 90 degrees to Grade	Planting orchards and performing tractor work 90 degrees to the grade to reduce erosion and provide for greater water penetration and retention. Practice is very site-specific and would not be easily adaptable to many existing orchards, particularly those that are flood irrigated.	
Aeration	Use of specialized tillage equipment to break crusts and aerate orchard soils with the intent of increasing water penetration and retention, thus reducing runoff. Aeration improves the soil profile with minimal disruption to the orchard floor. Aeration may reduce OP pesticide runoff although no studies have been conducted.	

Ripped Resident Vegetation	In orchards with permanent or semi-permanent sod, vegetation is ripped at various lengths and/or depths. Ripping significantly increases soil water due to increased infiltration and porosity. Heavy rains after fall ripping can leave orchards impassable to heavy equipment such as orchard sprayers. In recent research, ripped resident vegetation performed the best for infiltration and reduced diazinon transport, followed by non-ripped resident vegetation and bare ground being the least effective.	
Improving soil texture (tilth)	Practices such as tillage, gypsum applications or actions of earthworms have potential to increase water penetration and reduce runoff in compacted soils or where an impermeable soil layer exists. However, no studies have been conducted to show efficacy in reducing OP pesticide runoff with these approaches.	
	Benefits	Increased water penetration resulting in less runoff and increased recharging of the soil profile. Less water runoff means less potential for pesticides to be transported off-site.
	Drawbacks	Tillage can increase erosion under some conditions and necessitate additional orchard floor finishing work (scraping). Results vary with soil type and, under some conditions, compaction could increase. Improved soil permeability may increase movement of nitrate and other chemicals into groundwater. The balance of benefits versus disadvantages is not clear at this time and more research is needed.

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Walnut Production Manual: University of California, Division of Agriculture and Natural Resources. 1997. 328pp.

Crop: Winegrapes	
Compilation of Best Management Practices to Protect Surface Water from Farm Runoff	
BMPs when using Fungicides, Insecticides, & Herbicides	
Improved Pest Monitoring	Monitor vineyard pests on a weekly basis and keep a written record of results.
Canopy management for Disease Control	To minimize spraying or dusting for diseases leaf removal, sterile shoot-thinning and shoot-positioning is practiced to improve air movement, enhance spray penetration, and lower canopy humidity (or the vine is well balanced, and leaf removal is not necessary to create this environment). Also irrigation, especially pre-veraison, is managed to reduce excess growth.
Timing of Treatments for Powdery Mildew	To minimize dusting or spraying treatments for powdery mildew are applied according to the grape powdery mildew disease index, based on weather data from a nearby weather station and past experience with the vineyard.
Treatment thresholds for leafhoppers and mites	To minimize spraying control decisions for leafhoppers, mites and thrips are based on economic thresholds such as leafhopper nymphs per leaf, numbers of leafhopper adults present, percent leaves infested with mites, and amount of leaf damage. For mites, control decisions are also based on percent leaves with mite predators present.
Choice of Herbicides	Herbicides prone to runoff or leaching, such as simazine, diuron, and norflurazon, are not used at all or the amount used is reduced by minimizing the berm width, and/or treating berms every second or third year.
Sprayer calibration and maintenance	To optimize spraying efficiency sprayer is calibrated, coverage checked and worn nozzles replaced every year, or whenever the tractor, tractor tires, or soil conditions dramatically change.
Spray coverage	To optimize spraying efficiency single row airblast sprayer is driven 3.5 mph or slower, and two-row and four row airblast, and over-the-vine high-pressure sprayers driven 2.5 mph or slower and nozzles are positioned, and opened or closed, as required during the season by the changing canopy.
Drift	The ability to detect products in streams and rivers at parts per trillion levels leaves little room for error. To prevent problems, equipment operators must take extra care when spraying near sensitive areas and bodies of water. Shutoff equipment at vinerow ends. Spraying and dusting is avoided when wind exceeds 5 mph, or the air is dead still, and nozzle pressure is maintained in the zone recommended by the nozzle manufacturer (often 40 psi) to avoid non-uniform droplets. Spraying and dusting is avoided when wind is blowing towards sensitive areas (e.g. homes, riparian areas, roads, and canals), and a reasonable buffer zone is maintained at all times, even if this means not treating some vines. Use of drift retardant chemicals in the spray mix. Although these are effective in reducing the number of drift-prone droplets, in most cases it is more effective to select the proper size and type of nozzles and operate sprayers at low pressure to produce the desired drop size, rather than attempt to increase droplet size with drift retardant chemicals.
Nutrient/Fertilizer Application BMPs	

<table>
<tr><td>Decision to Apply Nutrients</td><td colspan="2">When making a decision to apply nutrients the following are used as a guide: yearly leaf petiole or leaf blade samples and analyses, vine vigor, fruit quality, wine quality, leaf symptoms, water quality test (particularly nitrate concentration), and soil samples and analyses done every 5 years.</td></tr>
<tr><td>Form of Nutrients</td><td colspan="2">Obtain as much or the required nutrients as possible from natural sources such as cover crops, or the addition of the proper amounts of compost and/or manure.</td></tr>
<tr><td>Application Method and Timing</td><td colspan="2">Apply nutrients through drip irrigation system if possible. If fertigation is used ensure that irrigation does not result in off-site movement of water.
If nitrogen is applied it is done in at least two separate applications during the growing season or post-harvest but never when the vine is dormant.</td></tr>
<tr><td>Application Practices</td><td colspan="2">Clean-up fertilizer spills promptly.
Shut off fertilizer applicators during turns and use check valves when possible.
Maintain proper calibration of fertilizer application equipment.
Whenever injecting fertilizer into irrigation water, ensure backflow does not occur.
Rinse water from fertilizer tanks should be evenly spread throughout a field. Fertilizer tanks and equipment should be cleaned by rinsing in the field or at a properly designed wash facility. Rinse water and/or sludge should be evenly spread across a field using good agronomic practices.
When equipment is parked, use care to prevent material from leaking into storage area. If equipment is known to be in disrepair, completely remove fertilizer material before parking equipment.
When transferring fertilizer into on-farm storage or into a fertilizer applicator, take care not to allow materials to accumulate on the soil. Good housekeeping practices should be implemented to prevent contamination of groundwater and/or surface water.</td></tr>
<tr><td colspan="3">Winegrape Field Practice BMPs</td></tr>
<tr><td rowspan="3">Irrigation System</td><td colspan="2">Install a low volume system such as drip irrigation.</td></tr>
<tr><td>Benefits</td><td>Delivers water directly to point of need (ie. Vine root system); provides complete control over timing of irrigation which is crucial for producing optimum winegrape quality; can be used to deliver fertilizers and some soil amendments; increases water use efficiency.</td></tr>
<tr><td>Drawbacks</td><td>Drip irrigation systems are expensive to install.</td></tr>
<tr><td>Rainfall and Irrigation Runoff</td><td colspan="2">Prevention techniques, such as cover crops, are in place to prevent any rainfall run-off under normal storm conditions and minimize runoff during very high rainfall events. If significant run-off does occur during rainfall events install a drainage system to minimize off-site movement of silt, pesticides and fertilizers (see also Filter Ditches below). Any soil permeability problems have been addressed (e.g. through a cover crop or soil amendments). Schedule irrigation so that it creates no run-off.</td></tr>
<tr><td>Cover Crop Management</td><td>Cover and Green Manure Crop</td><td>Plants are disked to incorporate organic material and improve soil fertility and tilth. Disking (or mowing) is generally done around bud-break, depending on frost potential and soil moisture conditions.</td></tr>
</table>

	Mowed Cover Crop	Managed by mowing to maintain at least 60% ground cover where erosion is possible. Mowing to 3-4 inches prior to frost can reduce cold temperature damage potential. Mowing intervals can often allow adequate seed production for following season re-growth. Mowed cover crops reduce dust during harvest operations and improve water infiltration rates.
	Disked Cover Crop	Plants typically disked around bud-break, depending on condition of the target crop, weather and soil moisture conditions. Maintain at least 60% ground cover where erosion is possible. Mowing to 3-4 inches prior to frost can reduce potential for cold temperature damage.
Vegetative Buffers	Areas or strips of land surrounding a field that are maintained in permanent vegetation. To effectively trap pesticides, buffers must slow water runoff and increase infiltration so that pesticides can be trapped and degraded in buffer soil and vegetation. Vegetative buffers are a tool to further improve water quality and provide additional benefits such as wildlife habitat and stream bank protection. For best success, they should be used in conjunction with other mitigation practices.	
	Benefits	Can be used to manage soil, water, nutrients and pesticides while minimizing environmental impacts. Effective in trapping eroded sediment, reducing runoff of pesticides that are adsorbed to soil particles. Note: some pesticides (e.g. OPs) are highly water soluble and don't adsorb to soil particles as readily as others (e.g. pyrethroids).
	Drawbacks	California-based research is limited on the potential for filter strips and grassed waterways to reduce OP pesticide loading, although the practices have been shown to be effective in other regions of the U.S. Uncertainties of buffers include: appropriate dimensions for volume of water flow; appropriate plant species and plant density for the soil types and rainfall zones; considerations for various locations; slope and channel dimensions for grassed waterways; and dimensions for constructed wetlands. Can require growers to set aside productive acreage.
Vegetative Filter Strips	Areas of grass or other permanent vegetation used to reduce sediment, organics, nutrients, pesticides and other contaminants in runoff to maintain or improve water quality. Vegetative filter strips are located between crop fields and water bodies, i.e. grassed roadways. Plant material captures rainfall and retains nutrients. Roadways can be grassed or sod planted, as can sprayer mixing pads and wellheads. Depending upon the site, a full border around a field may not be necessary for mitigating impacts to surface water. Filter strips could be planted at tail ends of fields or in other critical zones.	
	Benefits	Slows runoff allowing sediment to drop out of suspension. Traps sediment with adsorbed pesticide residues. Increases water infiltration into the soil profile. Catches some pesticide drift, preventing it from reaching the soil.
	Drawbacks	If water runoff is channeled, a grass strip may not effectively trap the adsorbed pesticides.

Grassed Waterways	Natural or constructed channels planted in permanent vegetation and located in an area where runoff concentrates. Constructed waterways can be graded to carry surface water at a non-erosive velocity to a stable outlet. Waterways are most effective in trapping sediment and dissolved chemicals when designed to spread concentrated water flow evenly cross a vegetative filter adjacent to waterways.	
	Benefits	Helps slow the flow of water to a non-erosive level. Provides a means of trapping sediment, nutrients, and pesticides while preventing gully erosion. Provides habitat and cover for wildlife.
	Drawbacks	Overgrown channels causing waterway breaching and flooding can restrict storm flows. Due to the concentrated flow that normally occurs in waterways, sediment trapping and water infiltration can be minimal with large runoff events, but substantial with smaller events.
Filter Ditches	Areas filled with activated charcoal, peat, or other filtering agents at locations where water leaves the ranch. These would be replaced periodically and would filter pesticides before the soil solution reaches surface water.	
	Benefits	Further research is needed in California but other areas of the US have shown effective reduction of pesticide residue.
	Drawbacks	High cost due to materials and increased maintenance needed.
Riparian Buffers	Trees and shrubs planted adjacent to streams, lakes, ponds and wetlands. Forest buffers are frequently combined with an understory of perennial grass buffers.	
	Benefits	Helps lower water temperatures by shading the water body. Protects stream banks and slows out-of-bank flood flows. Deep tree roots may intercept nitrate entering streams in shallow subsurface flow and provide soil carbon for microbial energy. Microbes can denitrify nitrate and degrade pesticides. Woody vegetation provides food and cover for wildlife. Contributes energy sources to aquatic communities.
	Drawbacks	If water runoff is channeled, riparian buffers may not effectively trap pesticides.
Constructed Wetlands	Wetlands constructed at tile outlets or as part of riparian buffer systems for degrading pesticides and denitrifying nitrates**.**	
	Benefits	Provides confined area for breakdown of pesticides in water.
	Drawbacks	Land needed for constructed wetlands is not readily available in high production areas. Available land can be costly.
Hedgerows	Fences of shrubs or trees in, across, or around a field. Hedgerows can include an understory composed of perennial native grasses and forbs, a shrub midstory composed of California native species and occasionally a discontinuous overstory of valley and foothill trees.	

	Benefits	May reduce erosion by having perennial vegetation on a portion of the field. If runoff flows across the hedgerow in sheet flow, sediment can be trapped, reducing the amount of sediment and sediment-borne pesticides from entering surface waters. Can attract beneficial insects and provide competition against invasive weeds. Windbreaks and hedgerows can provide drift mitigation, potentially reducing off-site movement of pesticides. Because many of the native species used in hedgerows have deep roots that hold the soil and increase water permeability, there may be a reduction in water runoff and off site movement of sediment. This could reduce runoff of pesticides in the dissolved and sediment-borne phases of field runoff. However, no studies have quantitatively measured the reductions in OP pesticide runoff.
	Drawbacks	Certain plant species may attract pests that can attack the crop or neighboring crops. Careful consideration must be given to the species of vegetation selected and the types of insects that may be attracted. Plant species can provide habitat and attract endangered species. Safe Harbor Agreements are available to protect growers where a practice is implemented that could attract endangered species to their farms, a factor that should be evaluated and addressed before establishing hedgerows. Some species can grow 10-15 feet wide, so space must be allowed for equipment to pass.
Stewardship BMPs		
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Concrete or Asphalt Pad	Use concrete or asphalt pad that drains to a central sump	
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Equipment	Check equipment for cracked / broken hoses, valves, etc. Calibrate prior to each application. Use spray nozzles with large droplet size to minimize drift.	
Tank filling	Fill tank to 1/3 to ½ full prior to the addition of chemicals. Use air gap to prevent tank overfilling. Use backflow valve on the fill tube.	
Personnel	Person(s) always present during mixing/loading operations. Person(s) trained to take corrective action when necessary.	
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Cleanup	Mix rinseate with water and reapply to field. Clean equipment on appropriate pad at least 300 feet from surface waters. Triple rinse empty containers and dispose of in landfill or recycling area.	

Sediment Control BMPs		
Water and Sediment Control Basins	Constructed earth embankments or a combination ridge and channel. Constructed across the slope and minor watercourses to form a sediment trap and water detention basin.	
	Benefits	Trap sediment and pesticides adsorbed to soil particles. Reduce and manage onsite and downstream runoff. Divert the flow of dissolved substances such as nutrients and pesticides. Improve the farmability of sloping land, reduce water course and gully erosion. Improve downstream water quality.
	Drawbacks	Basins are not viable for many vineyard areas in California, primarily because considerable land acreage would be required to manage the volumes of water typically produced in rainfall events, especially in the Sacramento Valley.
PAM Applications	PAM is a polymer compound injected or fed into irrigation water at the head of a field supply ditch or discharge point. Applications rates range from 5-8 pounds per acre with the material typically metered into the head ditch with a gandy-type applicator	
	Benefits	In newly formed furrows, soil does not move down the row or erode when irrigation water is treated with PAM. Suspended soil particles drop out of irrigation water containing PAM. After an irrigation containing PAM, furrow erosion and transport of sediment is greatly reduced in subsequent irrigations. Erosion reductions of 95% have been documented in numerous field trials and commercial applications in the San Joaquin Valley.
	Drawbacks	Additional cost Is not effective in preventing solubilized pesticides from moving off-site. Studies only done with furrow irrigation. No information concerning drip irrigation.
Compaction / Wheel Rutting	Wheel ruts formed by equipment passing through wet fields can create channels for water and sediment to runoff from vineyards. Where possible, minimize creation of wheel ruts with dormant vineyard sprayers, brush shredders or other equipment when vineyard floor is saturated.	
Drainage System Management	Filtering runoff water through vegetation allowed to grow in drainage ditches may help mitigate offsite movement of sediment as well as pesticides dissolved in storm runoff.	
Avoiding Channelization of Streams and Creeks	Allowing streams to naturally flow and meander can increase runoff retention and infiltration. A modified or channeled stream could also be restored to a more natural state by re-establishment of the riparian vegetation, which also provides stream bank protection.	
Berms at Low Ends of Fields (sandy soils, low slope)	Raised berms at low ends of fields can trap sediment and adsorbed pesticides reducing runoff of dissolved substances in fields with low slopes and sandy soil types. Berms hold back water, increasing runoff retention and allowing infiltration.	

Aeration	Use of specialized tillage equipment to break crusts and aerate soils with the intent of increasing water penetration and retention, thus reducing runoff. Aeration improves the soil profile with minimal disruption to the floor if completed during dormant season. Aeration may reduce OP pesticide runoff although no studies have been conducted.	
Improving soil texture (tilth)	Practices such as gypsum (or sulfur in higher lime soils) and humic acid applications or actions of earthworms have potential to increase water penetration and reduce runoff in compacted soils or where an impermeable soil layer exists. However, no studies have been conducted to show efficacy in reducing OP pesticide runoff with these approaches.	
	Benefits	Increased water penetration resulting in less runoff and increased recharging of the soil profile. Less water runoff means less potential for pesticides to be transported off-site.
	Drawbacks	Results vary with soil type and, under some conditions, compaction could increase. Improved soil permeability may increase movement of nitrate and other chemicals into groundwater. The balance of benefits versus disadvantages is not clear at this time and more research is needed.

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