Implementation of Best Management Practices to Reduce Agricultural Total Maximum Daily Loads in the Calleguas Creek and Santa Clara River Watersheds: A Case Study of Water Contaminant Mitigation in California

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Abstract. Agriculture is a major industry in California, with cool-season crops grown along the state's coasts, warm-season crops grown in the hot deserts, and many temperate crops grown in the state's valleys. In coastal communities such as Ventura County, the Calleguas Creek and the Santa Clara River watersheds have 50,000 and 60,000 irrigated acres of farm crops, respectively. These watersheds are considered impaired by nutrients, salts, pesticides, and other agricultural contaminants. Mitigation of chemical and sediment runoff through grower-implemented best management practices (BMPs) is therefore one of the highest priorities in the Los Angeles Regional Water Quality Control Board Basin Plan. A 3-year project was designed to assist Ventura County growers in meeting regional water quality objectives. The University of California Cooperative Extension Ventura County and the University of California, Riverside, collaborated with the Ventura County Resource Conservation District and the Ventura County Agricultural Irrigated Lands Group (VCAILG) to address three project goals: increase grower and landowner understanding of local agricultural water quality issues; identify gaps or deficiencies in current management practices in agricultural operations; and reduce the contribution of nutrients, pesticides, and other pollutants to impaired water bodies. To achieve these goals, 469 surveys of agricultural water quality management practices were collected to assess the extent of current adoption of BMPs. Over 160 growers who farm more than 14,000 acres that drain into Calleguas Creek and 7,000 acres that drain into the Santa Clara River watersheds were assisted. Using the survey, growers developed site-specific farm water quality plans and received on-farm recommendations for BMPs. Additionally, 12 water quality educational programs, "including demonstrations of successful BMPs," were developed and more than 2500 copies of educational materials published by the University of California, the Resource Conservation District, and the Natural Resources Conservation Service of the U.S. Department of Agriculture were distributed at on-farm visits, workshops, and other grower events. The project resulted in improved understanding, by growers and landowners, of water quality issues and significantly increased the implementation of appropriate on-farm BMPs to protect water quality. Nearly 100 new BMPs primarily aimed at managing erosion, sediment movement, and irrigation runoff were identified and documented through annual reassessments for more than 8000 acres draining into Calleguas Creek. A total of 518 people attended the educational programs, and over 90% of participants who completed evaluations rated the programs highly. In the final year of the project, 75% of attendees indicated they plan to implement new BMPs within the next 5 years, especially in the areas of irrigation, erosion, and pest management.

Like other parts of the United States, impairment of water quality by agriculture is a major concern in California. In Ventura County, the Calleguas Creek (Fig. 1) and the Santa Clara River (Fig. 2) watersheds have 50,000 and 60,000 irrigated agricultural acres, respectively. These watersheds are considered impaired by agricultural contaminants such as nutrients, salts, and pesticides (U.S. Environmental Protection Agency, 2013). In

1967, California formed the State Water Resources Control Board (SWRCB, 2013) to oversee that the state maintains water quality and properly allocates its water sources for beneficial uses. The SWRCB developed nine Regional Water Quality Control Boards (RWQCBs). Each of these agencies is responsible for developing and enforcing water quality plans in their region, taking into consideration their region's differences in climate and water uses. The Calleguas Creek and Santa Clara River watersheds are under the jurisdiction of Region 9, the Los Angeles RWQCB. The Los Angeles RWQCB adopted a Conditional Waiver of Waste Discharge Requirements for those that discharge water from irrigated agricultural land (California State Water Resources Control Board, 2013). The current "Conditional Ag Waiver" for this region was adopted in Oct. 2010 and lasts for 5 years. The program requires that either individual land managers or "discharge groups"

such as farmers for a particular stream reach monitor water draining from irrigated agricultural land and implement additional BMPs as necessary to reduce nutrient and pesticide runoff. They must also complete 8 hours of farm water quality education (California Regional Water Quality Control Board, 2013; Newman, 2011).

A 3-year project was designed to assist Ventura County growers in meeting the regional water quality objectives. The co-operators in this project addressed three main goals: increase farmer and landowner understanding of local agricultural water quality issues; identify gaps or deficiencies in current management practices in agricultural operations; and reduce the contribution of nutrients, pesticides, and other pollutants to impaired water bodies. To achieve these goals, the project included: the dissemination of self-assessment questionnaires, documentation of current BMPs, and education and outreach to targeted grower groups.

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Fig. 1. Calleguas Creek watershed agricultural land use map (Ventura County Agriculture Irrigated Lands Group, 2010).

Fig. 2. Santa Clara River watershed agricultural land use map (Ventura County Agriculture Irrigated Lands Group, 2010).

DISSEMINATION OF SELF-ASSESSMENT QUESTIONNAIRES

To gather information about BMP use in the Calleguas Creek and Santa Clara watersheds, a survey of water quality management practices for agriculture was developed and distributed to growers in Ventura County at the beginning of 2009 by the VCAILG. VCAILG is a voluntary program consisting

of growers and landowners. This group is managed under the Farm Bureau of Ventura County but is funded through annual assessments to its members. The role of VCAILG is to hire consultants who will establish water-monitoring sites, collect and submit runoff water samples to independent laboratories for analyses, and report results to the appropriate state water agencies (Farm Bureau of Ventura County, 2013). The survey included

questions regarding 100 individual BMPs, which were classified into the following categories: sediment and erosion management, irrigation management, pest management, nutrient management, salinity management and leaching, and property management (Ventura County Agriculture Irrigated Lands Group, 2008). Surveys were mailed to landowners within VCAILG's first-tier priority and second-tier priority drainage areas on Mar. 2009 and Oct. 2009, respectively. These priority drainage areas were classified as first, second, or third tier based on the total number of benchmark exceedances, the number of classes of pollutants, the number of total maximum daily loads effective at the drainage point, and the percentage of agricultural acreage enrolled in the VCAILG. Drainages included in the first priority area were Oxnard Central Ditch (Oxnard Coastal watershed), La Vista Drain (Calleguas Creek watershed), and Todd Barranca and Piru Creek (Santa Clara River watershed) (Figs. 1 and 2). Drainages included in the second priority area were Mugu Lagoon, Revolon Slough, and Calleguas Creek (Calleguas Creek watershed) (Fig. 1).

Four hundred twenty-nine surveys that described management practices on the irrigated land were completed and returned. BMPs were evaluated for the constituents that produced water quality benchmark exceedances during VCAILG monitoring in 2007 and 2008. Monitoring data collected by VCAILG to characterize conditions in Calleguas Creek before project implementation indicated that most exceedances of water quality benchmarks were the result of nitrate, organochlorine (forms of DDT, chlordane, and toxaphene), and organophosphorus pesticides (diazinon and chlorpyrifos) as well as salts at some sites (Ventura County Agriculture Irrigated Lands Group, 2010). Results of the surveys (2009 benchmark data) indicate that growers implemented new BMPs after Jan. 2008 in all of the priority drainages areas where exceedances occurred; however, some BMP categories had not been implemented for specific targeted constituents at this time. BMPs designed for sediment/erosion management and salinity/leaching management were less widely implemented in the priority drainages than BMPs designed for management of irrigation, pests, nutrients, and property. Property management was the most prevalent BMP category in use in the priority drainages with an overall average use of 98% for each priority constituent (nitrogen, organochlorine, and organophosphorus pesticides) across the second-tier priority areas (Table 1).

DOCUMENTATION OF BEST MANAGEMENT PRACTICES

Between 1 May 2009 and 31 Mar. 2012, 161 farmers and landowners farming 14,287 acres draining to the Calleguas Creek watershed and 7,304 acres draining to the Santa Clara River watershed were assisted with on-site farm water quality management planning (Table 2). Based on site conditions such as

Table 1. Percentage of acreage within the Calleguas Creek and Santa Clara watersheds where best management practices (BMPs) were implemented to mitigate benchmark exceedances of nitrate, organochlorine, and organophosphorus pesticides (n = 429 surveys) in 2009 (Ventura County Agriculture Irrigated Lands Group, 2010).^z

Best Management Practice	Percentage of surveyed acreage (%)					
	Nitrate ^y		Organochlorine pesticides ^x		Organophosphorus pesticides ^w	
	First priority ^v	Second priority ^u	First priority	Second priority	First priority	Second priority
Erosion and sediment	63 ^t	50	63	58	64	54
Irrigation	87	86	83	86	83	86
Pest	N/A	N/A	N/A	N/A	93	98
Nutrients	88	94	N/A	N/A	N/A	N/A
Salinity	71	93	N/A	N/A	N/A	N/A
Property	95	98	96	98	90	92

^zAcreage percentage is presented by BMP type and targeted constituents.

^yNitrate benchmark is 10 mg·L⁻¹.

^x4,4-DDT compounds benchmark is 0.00059 µg·L⁻¹.

^wChlorpyrifos benchmark is 0.025 µg·L⁻¹. Diazinon benchmark is 0.1 µg·L⁻¹.

^vDrainages included in the first priority area: Oxnard Central Ditch (Oxnard Coastal watershed), La Vista Drain (Calleguas Creek watershed), and Todd Barranca and Piru Creek (Santa Clara River watershed).

^uDrainages included in the second priority area: Mugu Lagoon, Revolon Slough, and Calleguas Creek (Calleguas Creek watershed).

^tFor details on acreage calculations (Ventura County Agriculture Irrigated Lands Group, 2010).

N/A = not applicable.

Table 2. Number of acres impacted with on-site water quality management plans in the Calleguas Creek and Santa Clara River watersheds from May 2009 to Mar. 2012 based on surveys conducted with growers and landowners during this time period.^z

Crop	Calleguas Creek		Santa Clara River	
	Acreage assisted	Percentage of total agricultural acreage assisted in watershed	Acreage assisted	Percentage of total agricultural acreage assisted in watershed
Orchard	3,671	26%	3,809	52%
Nursery	64	1%	1,457	20%
Row	5,343	37%	333	5%
Strawberry	3,129	22%	1,565	21%
Other berries	2,080	15%	140	2%
Total	14,287		7,304	

^zData are presented by crop type.

topography, microclimate, and crop type, various types of BMPs were suggested during these consultations. Most recommendations included sediment and erosion management practices and irrigation management practices. During the 3-year project period, newly implemented BMPs were documented on 53 properties in the Calleguas Creek watershed, representing over 9800 acres (Table 3). This acreage represents 18% of the estimated agricultural acreage in the watershed (the total acreage of Calleguas Creek watershed is 219,520 acres with an estimated 25% in agricultural land use). Various BMPs were implemented with irrigation management being implemented in all stream reaches (Table 4). Some growers expressed that more efficient irrigation management during the dry season would result in reduced runoff, because most runoff during the dry season results from improper irrigation. Growers on level terrain close to sea level often installed tile drains and pumps to reduce water levels on their fields, so improved irrigation management would minimize additional tile drain pumping. Sediment and erosion management was also frequently implemented by growers.

EDUCATION AND OUTREACH

Twelve educational programs were developed and conducted. These programs included classroom lectures and demonstrations and

tours of farms showcasing successful BMP implementation. Meetings were open to growers in all Ventura County watersheds as well as growers in other counties. The educational programs were also used by VCAILG members and farmers from other agricultural areas to obtain "Ag Waiver" credits. Each workshop included a survey to assess whether the information presented was useful in implementing BMPs. Additionally, more than 2500 copies of several educational materials published by the University of California, the Resource Conservation District, and the Natural Resources Conservation Service of the U.S. Department of Agriculture were distributed at on-farm visits, workshops, and other grower events to enhance adoption of BMPs.

Over 55% of meeting attendees completed program evaluations when averaged for all 12 workshops. Over 90% of these attendees rated the workshops and tours as "informative," the highest rating of the choices provided. At eight workshops conducted between May 2009 and June 2011, attendees were asked whether participating in a previous educational program resulted in implementation of a BMP; over 55% of respondents indicated this was the case. Irrigation and property management BMPs were among the most widely adopted after attending an education meeting. Beginning in June 2011, attendees were asked about

Table 3. Number of properties and total acreage in which best management practices were implemented between May 2009 and Mar. 2012 based on surveys conducted with growers and landowners during this time period.^z

Calleguas Creek stream reach	Number of properties	Acreage
Mugu Lagoon	2	625
Calleguas Creek 2	6	393
Calleguas Creek 3	1	9
Revolon Slough	10	4751
Beardsley Channel	12	1431
Arroyo Las Posas	13	965
Conejo Creek A	2	53
Conejo Creek B	4	98
Arroyo Santa Rosa	3	8
Total	53	8333

^zData are presented by stream reach in the Calleguas Creek watershed.

planned BMP implementation as a result of attending the meeting being evaluated. Approximately 75% of respondents indicated they would adopt new BMPs in the next 5 years, particularly for irrigation, erosion, and pest management. The results of program evaluations highlight the importance of educational workshops and tours. Not only were these meetings rated highly by growers, property managers, and other affiliates, but attendance also led to immediate implementation of BMPs as well as future plans for further BMP adoption.

CONCLUSIONS

This 3-year, collaborative project resulted in improved understanding, by growers and landowners, of water quality issues and significantly increased the implementation of appropriate BMPs to protect water quality. Nearly 100 new BMPs, primarily aimed at managing erosion, sediment movement, and irrigation runoff in more than 8000 acres draining into Calleguas Creek, were identified and documented. A total of 518 people attended the educational programs, and over

Table 4. Total acreage in each of the Calleguas Creek watershed stream reaches in which best management practices (BMPs) were implemented from May 2009 to Mar. 2012 based on surveys conducted with growers and landowners during this time period.²

BMP	Mugu Lagoon	Calleguas Creek 2	Calleguas Creek 3	Revolon Slough	Beardsley Channel	Arroyo Las Posas	Conejo Creek A	Conejo Creek B	Arroyo Santa Rosa
Sediment and erosion	365	368		2,335	400	694		50	
Irrigation	260	25	9	4,251	1,007	959	53	98	8
Pest				1,656	444			48	
Nutrient				3,674	21				
Property				2,120	23			48	
Total	625	393	9	14,036	1,895	1,653	53	244	8

²Data are presented by BMP type. One property may have multiple implemented BMPs. Therefore, specific acres within a stream reach may be included in more than one type of BMP.

90% of participants who completed evaluations rated the programs highly. In the final year of the project, 75% of attendees indicated they plan to implement new BMPs within the next 5 years, especially in the areas of irrigation, erosion, and pest management.

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