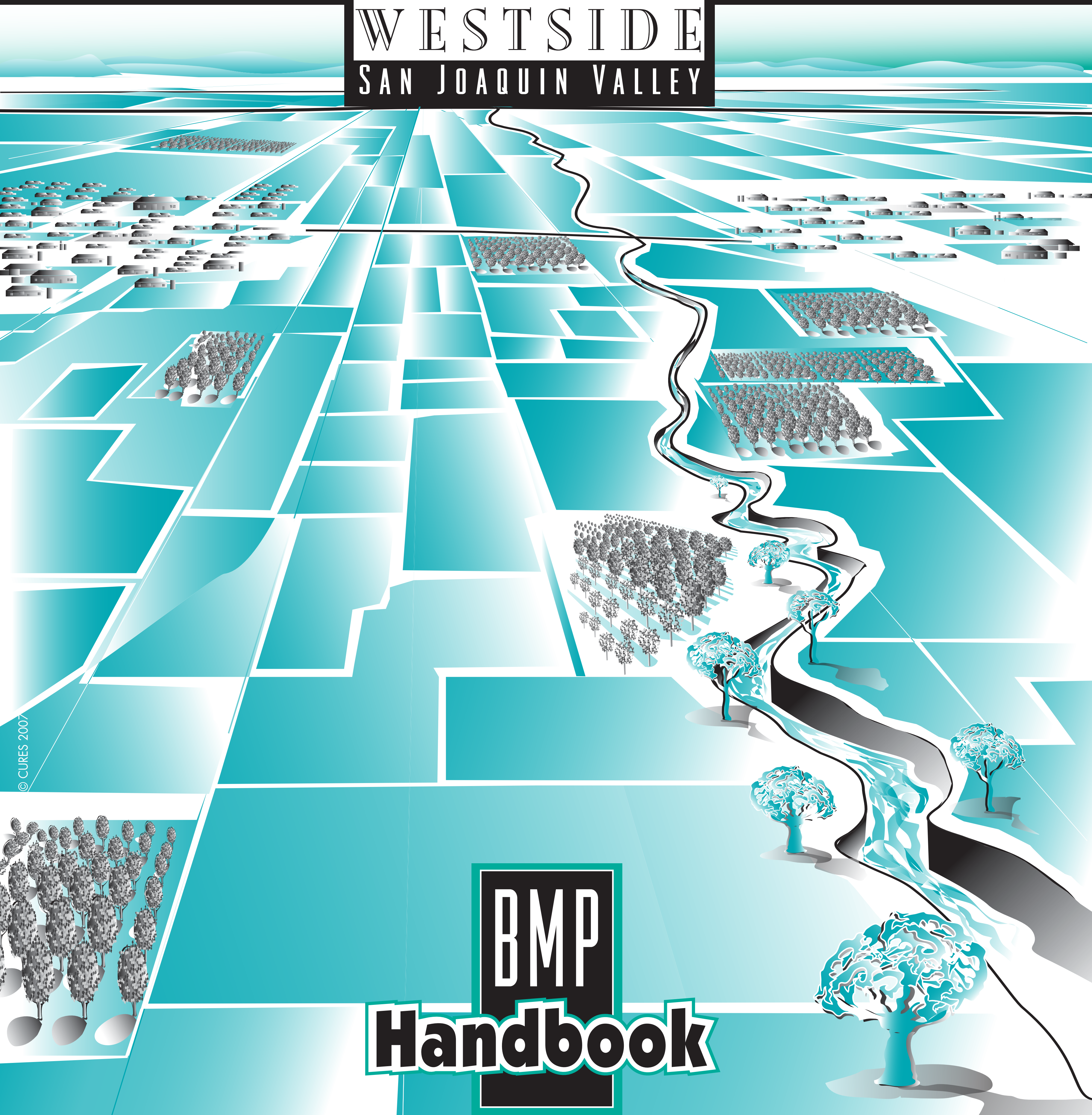
BMP Handbook

WESTSIDE
SAN JOAQUIN VALLEY



BMP Handbook

MANAGEMENT PRACTICES FOR PROTECTING WATER QUALITY

CONTENTS

BMP Handbook

INTRODUCTION

The ***Western San Joaquin Valley Pesticide BMP Implementation Program,*** funded by a grant from the State Water Resources Control Board, is a project to evaluate Best Management Practices (BMPs) for irrigated agriculture and provide updated information on installation and maintenance of these practices. The BMPs also have applicability in other agricultural regions of the Central Valley.

This revised version ***Westside San Joaquin Valley BMP Handbook*** is part two of a three phase program intended to encourage and increase BMP implementation in Orestimba Creek and Del Puerto Creek watersheds to reduce or eliminate pesticide, nutrient and other contaminant loads carried by irrigation return flows and storm water into the Orestimba Creek, Del Puerto Creek and subsequently the San Joaquin River.

Contained in this BMP Handbook is information on farming practices such as sediment basins, PAM, enzyme treatments, tailwater return systems, vegetative ditches, irrigation scheduling and others. These documents are summaries of technical reports developed for this project by the California Water Institute, Ducks Unlimited, California Department of Pesticide Regulation and others. Also included in this binder are booklets developed by CURES covering BMPs for commonly used pesticides. The complete reports and booklets are available on request by contacting CURES by mail or at www.curesworks.org.

Funding for this project has been provided in full or in part through an Agreement with the State Water Resources Control Board (SWRCB) pursuant to the Costa-Machado Water Act of 2000 (Proposition 13) and any amendments thereto. The contents of this document do not necessarily reflect the views and policies of the SWRCB, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

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STATE WATER RESOURCES CONTROL BOARD
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SAN LUIS & DELTA-MENDOTA WATER AUTHORITY

BMP Handbook

INTRODUCTION

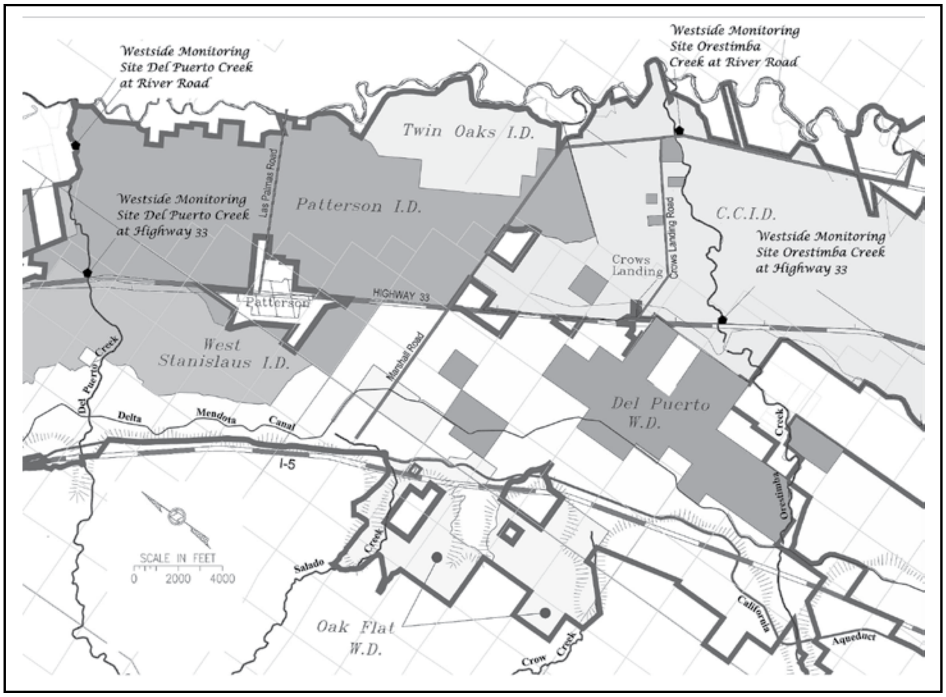
Water and Sediment Monitoring Results

Orestimba/Del Puerto Creeks 2004 – 2007

The Westside San Joaquin River Watershed Coaliton (coalition) performs water and sediment sampling in 19 waterways between Tracy and Mendota, west of the San Joaquin River, including Orestimba and Del Puerto Creeks. This sampling is part of the coalition's requirements under the Irrigated Lands Regulatory Program of the Central Valley Regional Water Quality Control Board.

Water sampling occurs monthly throughout the year. Irrigation sampling (March through August) includes field, general chemistry and drinking water parameters and pesticide and toxicity screenings. Non-irrigation season sampling (September through February) includes field, general chemistry and drinking water parameters. Runoff from two storm events is also sampled and tested for chemical and pesticide constituents as well as toxicity. Sediment samples are tested for toxicity twice annually in spring and late summer. All sampling is performed under a Quality Assurance Program Plan.

Because water sampling of Orestimba Creek and Del Puerto Creek has found two or more exceedances of several pesticide standards, the Coalition is required to develop "Management Plans" for those waterways. Management plans are work plans, written by the Coaliton and approved by the Water Board, that describe known and potential sources of water quality problems and detailed actions by farmers to address those problems, including adoption of farming Best Management Practices (BMP). The coalition's plan focuses on efforts to address exceedances of particularly chlorpyrifos (Lorsban, Lock-On, Govern) and pyrethroid insecticides (Capture, Warrior, Asana, Pounce, etc.) which are transported in water or sediment carried by irrigation or storm water drainage.



The information on the following pages covers monitoring performed between January 2004 and September 2007.

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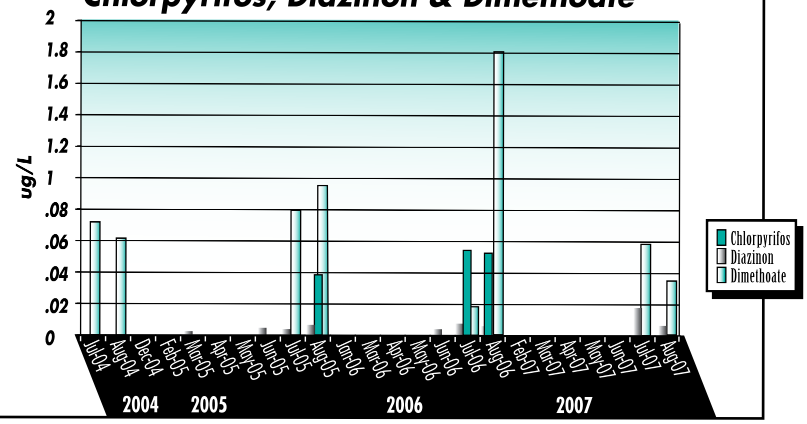
Orestimba Creek Results

Orestimba Creek at River Road (July 2004 through August 2007)

Concentrations of Chlorpyrifos, Diazinon & Dimethoate

Date	Chlorpyrifos	Diazinon	Dimethoate
Jul-04	ND	ND	0.72
Aug-04	ND	ND	0.61
Dec-04	ND	ND	ND
Feb-05	ND	ND	ND
Mar-05	0.015	ND	ND
Apr-05	ND	ND	ND
May-05	ND	ND	ND
Jun-05	0.043	ND	ND
Jul-05	0.035	ND	0.79
Aug-05	0.063	0.39	0.95
Jan-06	ND	ND	ND
Mar-06	ND	ND	ND
Apr-06	ND	ND	ND
May-06	ND	ND	ND
Jun-06	0.032	ND	ND
Jul-06	0.51	0.017	0.19
Aug-06	0.052	0.033	1.8
Feb-07	ND	ND	ND
Mar-07	ND	ND	ND
Apr-07	ND	ND	ND
May-07	ND	ND	ND
Jun-07	ND	ND	ND
Jul-07	0.17	ND	0.58
Aug-07	0.056	ND	0.35

ND= Non Detection

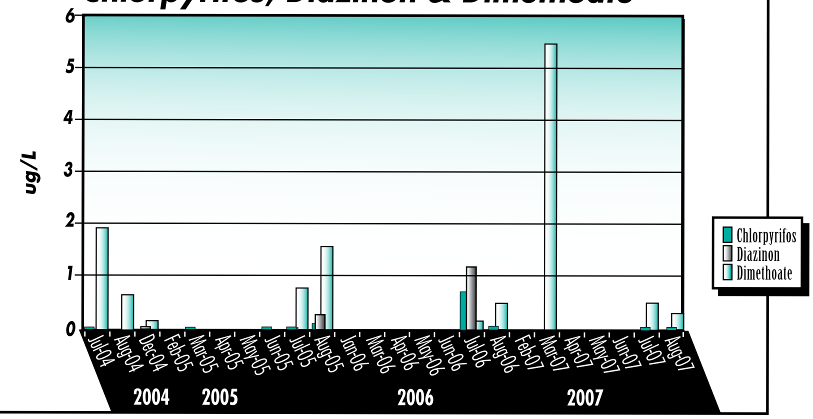


Orestimba Creek at Highway 33

Concentrations of Chlorpyrifos, Diazinon & Dimethoate

Date	Chlorpyrifos	Diazinon	Dimethoate
Jul-04	0.02	ND	1.9
Aug-04	ND	ND	0.67
Dec-04	ND	0.021	0.16
Feb-05	ND	ND	ND
Mar-05	0.014	ND	ND
Apr-05	ND	ND	ND
May-05	ND	ND	ND
Jun-05	0.029	ND	ND
Jul-05	0.032	0.031	0.8
Aug-05	0.12	0.28	1.6
Jan-06	ND	ND	ND
Mar-06	ND	ND	ND
Apr-06	ND	ND	ND
May-06	ND	ND	ND
Jun-06	ND	ND	ND
Jul-06	0.72	1.2	0.17
Aug-06	0.051	0.01	0.52
Feb-07	ND	ND	ND
Mar-07	ND	ND	5.5
Apr-07	ND	ND	ND
May-07	ND	ND	ND
Jun-07	ND	ND	ND
Jul-07	0.037	ND	0.53
Aug-07	0.023	ND	0.33

ND = Non Detection

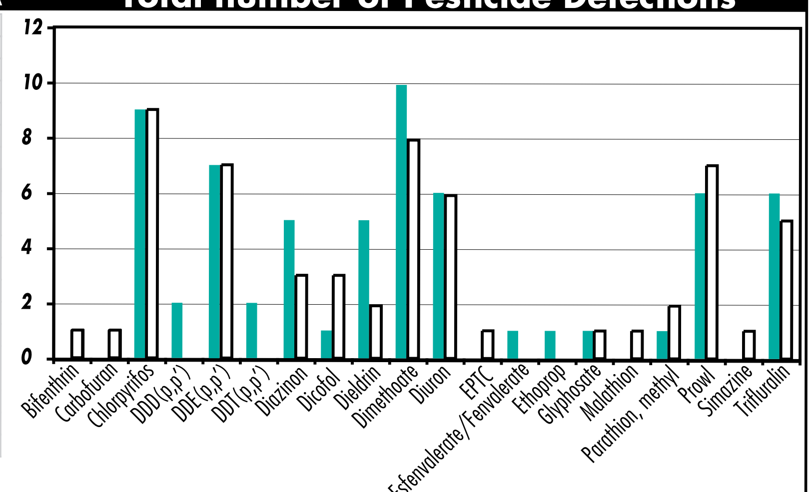


Pesticide Detections

Total number of Pesticide Detections

Analyte	*OCAHW	**OCARR
Bifenthrin	ND	1
Carbofuran	ND	1
Chlorpyrifos	9	9
DDD(p,p')	2	ND
DDE(p,p')	7	7
DDT(p,p')	2	ND
Diazinon	5	3
Dicofol	1	3
Dieldrin	5	2
Dimethoate	10	8
Diuron	6	6
EPTC	ND	1
Esfenvalerate/Fenvalerate	1	ND
Ethoprop	1	ND
Glyphosate	1	1
Malathion	ND	1
Parathion, methyl	1	2
Prowl	6	7
Simazine	ND	1
Trifluralin	6	5

ND = Non Detection



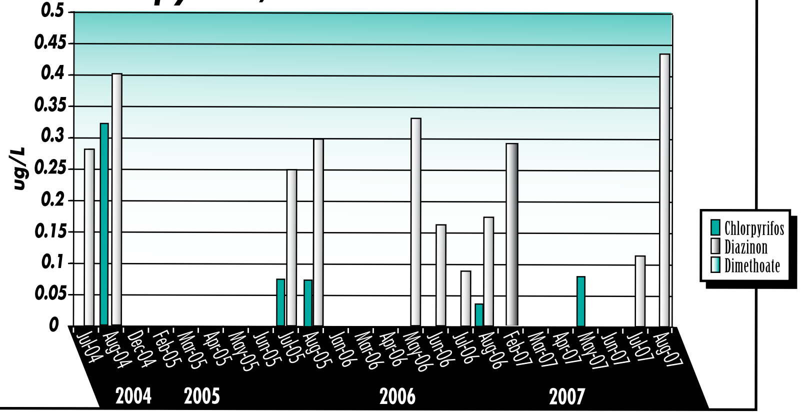
Del Puerto Creek Results

Date	Chlorpyrifos	Diazinon	Dimethoate
Jul-04	ND	ND	0.28
Aug-04	0.32	ND	0.4
Dec-04	ND	ND	ND
Feb-05	ND	ND	ND
Mar-05	ND	ND	ND
Apr-05	ND	ND	ND
May-05	ND	ND	ND
Jun-05	ND	ND	ND
Jul-05	0.073	ND	0.25
Aug-05	0.07	ND	0.3
Jan-06	ND	ND	ND
Mar-06	ND	ND	ND
Apr-06	ND	ND	ND
May-06	ND	ND	0.33
Jun-06	ND	ND	0.16
Jul-06	ND	ND	0.087
Aug-06	0.033	ND	0.17
Feb-07	ND	0.29	ND
Mar-07	ND	ND	ND
Apr-07	ND	ND	ND
May-07	0.076	ND	ND
Jun-07	ND	ND	ND
Jul-07	ND	ND	0.11
Aug-07	ND	ND	0.43

ND = Non Detection

Del Puerto Creek Near Cox Road *July 2004 through August 2007*

Concentrations of Chlorpyrifos, Diazinon & Dimethoate

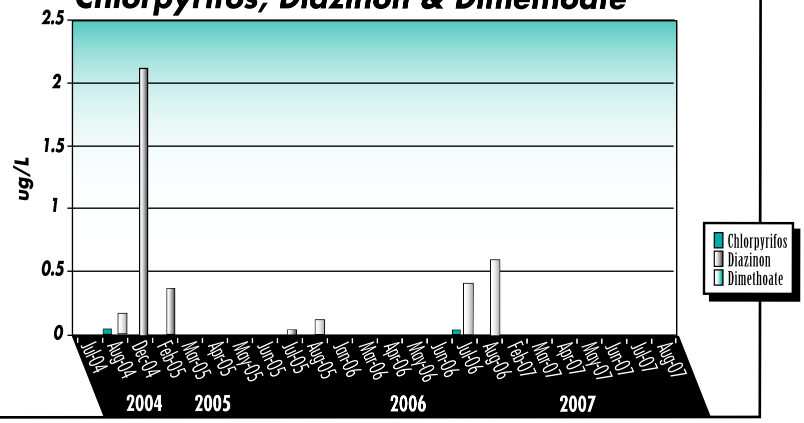


Date	Chlorpyrifos	Diazinon	Dimethoate
Jul-04	ND	ND	ND
Aug-04	0.025	ND	0.27
Dec-04	ND	2.1	ND
Feb-05	ND	0.037	ND
Mar-05	ND	ND	ND
Apr-05	ND	ND	ND
May-05	ND	ND	ND
Jun-05	ND	ND	ND
Jul-05	ND	0.013	ND
Aug-05	ND	ND	0.12
Jan-06	ND	ND	ND
Mar-06	ND	ND	ND
Apr-06	ND	ND	ND
May-06	ND	ND	ND
Jun-06	ND	ND	ND
Jul-06	0.014	ND	0.43
Aug-06	ND	ND	0.51
Feb-07	ND	ND	ND
Mar-07	ND	ND	ND
Apr-07	ND	ND	ND
May-07	ND	ND	ND
Jun-07	ND	ND	ND
Jul-07	ND	ND	ND
Aug-07	ND	ND	ND

ND = Non Detection

Del Puerto Creek at Highway 33 *July 2004 through August 2007*

Concentrations of Chlorpyrifos, Diazinon & Dimethoate

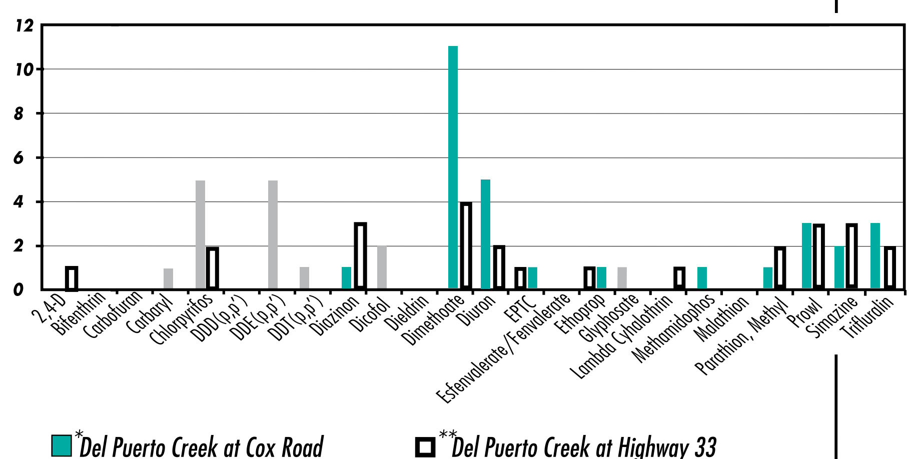


Pesticide Detections

Analyte	*DPCCR	**DPCHW
2,4-D	ND	1
Bifenthrin	ND	ND
Carbofuran	ND	ND
Carbaryl	1	ND
Chlorpyrifos	5	2
DDD(p,p')	ND	ND
DDE(p,p')	5	ND
DDT(p,p')	1	ND
Diazinon	1	3
Dicofol	2	ND
Dieldrin	ND	ND
Dimethoate	11	4
Diuron	5	2
EPTC	1	1
Esfenvalerate/Fenvalerate	ND	ND
Ethoprop	1	1
Glyphosate	1	ND
Lambda Cyhalothrin	ND	1
Methamidophos	1	ND
Malathion	ND	ND
Parathion, Methyl	1	2
Prowl	3	3
Simazine	2	3
Trifluralin	3	2

ND = Non Detection

Total number of Pesticide Detections



DEL PUERTO CREEK

DEL PUERTO CREEK - ORESTIMBA CREEK

Sediment Toxicity Results *September 2004 through September 2007*

Date	Del Puerto Creek at Cox Rd	Del Puerto Creek at Hwy 33	Orestimba Creek at River Rd	Orestimba Creek at Hwy 33
	Toxicity (Y/N)	Toxicity (Y/N)	Toxicity (Y/N)	Toxicity (Y/N)
September '04	N	N/S	N	Y
March '05	N/S	Y	Y	N/S
October '05	Y	Y	N	Y
March '05	Y	Y	N	N
September '06	Y	Y	N	Y
March '07	Y	Y	N	Y
September '07	N	Y	N	N

Test species in all samples was *Hyalella azteca*
N/S indicates no sediment sample taken on that date.

NOTES

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Sediment Basins

On site practices for protecting surface water can include modifying small areas of a field so drainage water from irrigations or storms passes through specially designed structures. These structures can assist in removal of sediment and farm inputs.

Sediment Basin Description

The most commonly used drainage management structure in the Central Valley is the sediment pond or silt basin. Sediment basins are typically simple in design and maintenance. Sediment basins used in agriculture reduce erosion and improve water quality by trapping water, sediment and potential pollutants. They can be effective to manage runoff from both winter storms and irrigation.

Sediment basins are located at the end of tail water ditches and collect drainage water, allowing time for sediment in the runoff to settle out. The runoff flows through the basin at a low velocity so sediment drops to the bottom of the pond. Water releases slowly through soil infiltration or a pipe outlet, improving the quality of the water leaving the basin.

Sediment basins are most effective when used in conjunction with other field-level erosion control practices, such as irrigation scheduling, use of polyacrylamide (PAM), vegetated filter strips or vegetated ditches/swales. Use of these practices can also reduce the costs of maintaining the sediment basin.

Sediment basins can be very cost-effective because they can be easily constructed with farm machinery and are efficient for most soil types. Sediment basins can also be used in conjunction with tailwater recovery systems.

Advantages

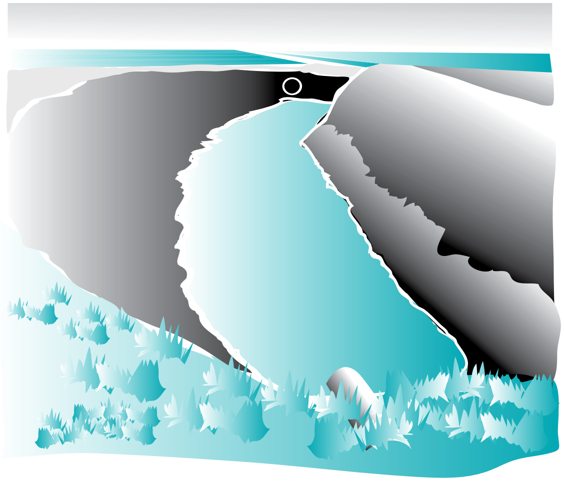
- Reduces sediment leaving property
- Enhances downstream water quality
- Possible pollution reduction
- Can provide near complete off-farm sediment control

Disadvantages

- Requires frequent clean out
- Sediment mounds must be spread on fields
- Loss of farmable acres
- To handle large quantities of off-farm sediment, basins can be expensive to install and maintain

*Design and Construction**

Sediment basins should be long and narrow so that sediment carried in the water has sufficient time to settle out before the tail water passes through. The length-to-width ratio can vary, but optimum settling can be achieved when the length is about three to four times greater than the width. Generally, the embankment should have a minimum top width of 4 feet and side slopes of 2:1 or flatter. The embankment top and edge can be planted with vegetation (annual, non-native perennial or native perennial grasses) to help prevent sloughing and erosion. The outlet should be lower than the inlet structure/inflow level of the basin. Outlet structures can be flashboard riser type to allow for ponding and outflow control.



SEDIMENT BASINS

SEDIMENT BASINS Central Valley Installation and Maintenance Costs

Sediment basins should be designed to store at least one year's accumulation of sediment. Natural Resource Conservation Service (NRCS) technicians can assist in computing sediment yield. A drying area is needed so sediment can dry after it is removed. Dredged sediment can be used to increase the bank height and therefore the capacity of the basin, or can be spread on adjacent farmland.

*The USDA Natural Resource Conservation Service National Practice Standard 350 addresses the general design and installation of sediment basins. Local NRCS technical advisors can provide site-specific specifications.

Maintenance

Maintenance costs are directly proportional to the field size and sediment yield. Reducing sediment yield before it enters the pond will reduce the cost significantly. It is recommended that other sediment management practices be installed in conjunction with a sediment basin. The construction cost is a one-time cost: maintenance is a continuous cost to keep the sediment basin operating properly.

For best operation, sediment basins and structural components should be inspected regularly and restored as needed. Maintenance activities include removal of collected sediment, repair of rodent holes, vehicular traffic, seepage, erosion, or woody vegetation. Drainage outlets should be periodically checked for clogging and/or pipe damage.

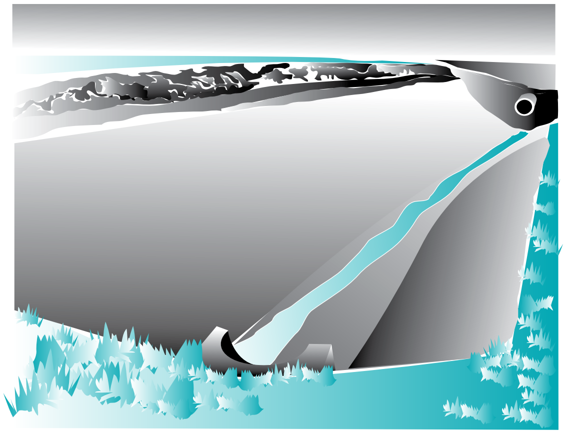
Below are cost estimates for hiring a subcontractor to install and maintain sediment basins in 2005:

Central Valley Construction/Maintenance Costs

Costs for Contractor-Installed Sediment Basin; 2005 estimate

Item	Costs* 30' x 200'	30' x 400'
Installation	$2,675	$3,175
Annual maintenance (silt removal)	$ 925	$1,375

*Including $175 equipment transport



SEDIMENT BASINS Central Valley Installation and Maintenance Costs

Example Construction/Maintenance Costs (Based on Central Coast study)

Sediment Basins Non-Engineered Water/Sediment Control Basin (237 Cubic Yards) – Partial Budget – Central Coast – 2003

COSTS PER UNIT*	ESTIMATED COSTS				POTENTIAL BENEFITS		
Installation (Year 1)	LOW	REP**	HIGH	ADDITIONAL RETURNS PER UNIT	LOW	REP	HIGH
Layout & Mark Site	$41	$41	$41	None	$0	$0	$0
Clear Site	$9	$9	$9				
Excavate & Compact Basins	$220	$440	$880				
Install Pipes, Couplers, Riser	$1,065	$1,431	$2,055				
Channel/Check Water-Sandbags	$0	$57	$154				
Plant Cover at Installation	$0	$45	$77				
(1a) Installation – Subtotal	***$1,335***	***$2,023***	***$3,216***				
Annual Operation & Maint. (Years 2-5):							
Remove & Redistribute Sediment	$330	$1,320	$2,310				
Mow Basin Perimeter	$0	$12	$54				
Spot Spray-Herbicide	$9	$13	$31				
Plant Annual Cover	$0	$45	$77				
Channel/Check Water-Sandbags	$0	$57	$154				
(1b) Ann. Oper. & Maint. Costs – Subtotal	**$339**	**$1,447**	**$2,626**				
Interest on Operating Capital @ 7.4%	$9	$21	$35				
(1c) Costs – Subtotal	*$1,683*	*$3,491*	*$5,877*	*(5) Additional Returns – Subtotal*	*$0*	*$0*	*$0*
REDUCED RETURNS PER UNIT	**LOW**	**REP**	**HIGH**	**REDUCED COSTS PER UNIT**	**LOW**	**REP**	**HIGH**
Strawberry Acreage Removed (.1 Ac)	$15	$570	$1,125	Labor & Equip. Use for Prevention & Repairs	$0	$650	$1,950
(2) Reduced Returns – Subtotal	*$15*	*$570*	*$1,125*	(6) Reduced Costs – Subtotal	$0	$650	$1,950
COSTS & REDUCED RETURNS	**LOW**	**REP**	**HIGH**	**ADD. RETURNS & REDUCED COSTS**	**LOW**	**REP**	**HIGH**
(3) Totals Per Unit Year 1 (1c+2)	*$1,698*	*$4,061*	*$7,002*	*(7) Totals Per Unit Year 1 (5+6)*	*$0*	*$650*	*$1,950*
(4) Totals Per Unit Per Year – Years 2-5 (1b+2)	*$354*	*$2,017*	*$3,751*	*(8) Totals Per Unit Per Year – Years 2-5 (5+6)*	*$0*	*$650*	*$1,950*

	LOW	REP	HIGH
NET CHANGE IN INCOME PER UNIT (Basin = 237 cubic yards) YEAR 1 (7-3)	-$1,698	-$3,411	-$5,052
NET CHANGE IN INCOME PER UNIT (Basin = 237 cubic yards) PER YEAR – YEARS 2-5 (8-4)	-$354	-$1,367	-$1,801
NET CHANGE IN INCOME PER CUBIC YARD YEAR 1	-$7	-$14	-$21
NET CHANGE IN INCOME PER CUBIC YARD YEARS 2-5	-$1	-$6	-$8

*Unit = Basin = 237 cubic yards; 1,600 square foot area with a 4 foot depth.

**Rep = Representative Cost.

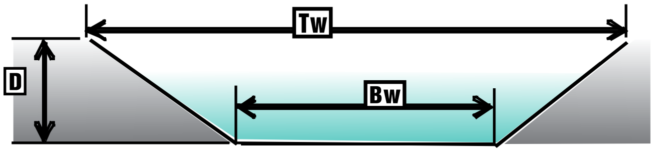
Excel Spreadsheet for Tailwater Pond Design

Please Fill in the information Below:

Notes	Item	Value	Unit
1	Total size of the fields that will drain into the pond	205	(acres)
2	Typical annual applied water	4	(af/acre)
3	Typical turnout delivery	7	(cubic feet per second)
4	Typical number of irrigations per season	10	
* 5	Tailwater Fraction	25%	(% of Applied Water)
*6	Pond Hold Time	12	(hours)
* 7	Operating Depth (D)	5	(feet)
* 8	Length / Width	1	(1 will provide a square pond)

* Assumptions (Typical values: adjust to fit specific field conditions)

Use the Excel spreadsheet in the CD below to calculate the size of tailwater pond to fit your field. The example below shows the information needed and the design parameters it will produce.



Calculation accounts for drained acreage, applied water rate and amount of suspended solids

Pond Dimensions		
Top Width (Tw)	131	(feet)
Bottom Width (Bw)	116	(feet)
Length (L)	131	(feet)
Depth (D)	5	(feet)
Total Volume	1.8	(acre feet)
Expected Annual Sediment Volume	155	(cubic yards)

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Vegetated Ditch/Grassed Waterway

On site practices for protecting surface water can include modifying small areas of a field so drainage water from irrigations or storms passes through specially designed structures. These structures can include vegetated ditches (also called grassed waterways or vegetated swales). While commonly used to buffer field runoff from rolling farm land in the Midwest, grassed waterways are only recently being tested and installed on Central Valley farms.

Vegetated Ditch Description

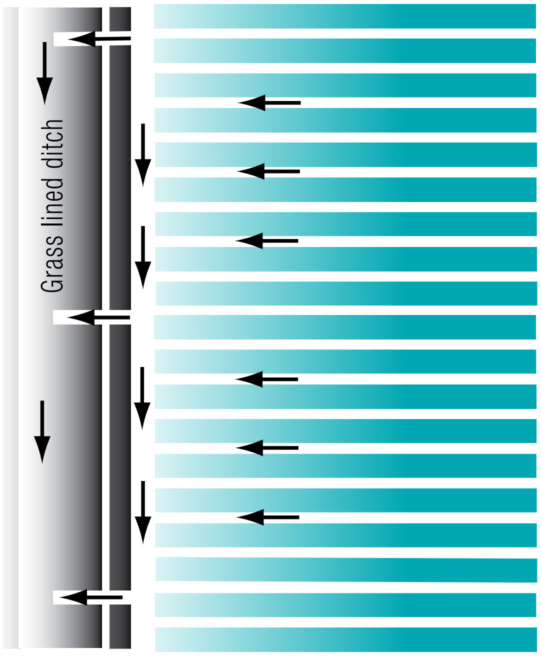
Vegetated ditches are wide, often shallow, low velocity channels used to transport irrigation or storm water drainage from fields to sumps or downstream waterways. A vegetated ditch (versus an earthen drainage ditch) has less ditch bank erosion and slows flow to enable sediment settling, thus reducing sediment transport potential. A vegetated ditch would be located at the lower end of a field where irrigation water drains. Vegetation would need to be established before the ditch is effective. When irrigation water is high in sediment, a settling pond may be needed to remove some portion of the suspended silt before flowing through the ditch. Excessive sediment in irrigation water can cause premature silting of the waterway.

Advantages

- Slows water movement and reduces sediment carried in surface flows
- Reduces ditch erosion
- Protection from overland flows
- May reduce farm input residues in drainage water (through filtration and biological action) when vegetation is properly maintained

Disadvantages

- Requires annual maintenance
- Acreage out of production
- Can potentially harbor pests
- Grass seed can be spread to other fields if tailwater is recirculated



Plan veiw of water flow into vegetated ditch

Design and Construction

Designs vary based on size of field and amount of drain water but a typical large grassed waterway has a 10-foot wide bottom with 4:1 side slopes. A smaller vegetated ditch can have a 6-foot wide bottom with 4:1 side slopes. Vegetated ditches typically require more land area than a standard drain ditch.

Ideal planting time is early fall so grass is well established before irrigation begins the following spring/summer. For optimum growth, fertilize and mow periodically. Irrigate after planting for best seedling establishment (unless rainfall occurs soon after planting). In the second year after planting, vegetated ditches can provide storm runoff benefits. Circulating storm runoff immediately after planting can wash out seedlings or reduce stand vigor. Experts in native grasses say that perennials need 18 to 24 months before they are adequately matured and most effective.

VEGETATED DITCH/GRASSED WATERWAY Central Valley Installation and Maintenance Costs

In 2003, U.C. Cooperative Extension estimated costs for grassed waterways on the Central Coast. Grassed waterways are similar in function and cross-section to vegetated ditches, and therefore their costs are provided below. Sizing allowances were made to assist cost comparison with other vegetated ditches.

UC Cooperative Extension Costs for Grassed Waterways

Item	Costs		
	Low	Mid	High
Installation*	$0	$1560	$3,638
Annual maintenance**	$71	$869	$2,025

* To clean waterways and smooth banks and plant erosion control mix
** To mow vegetation and clean waterway

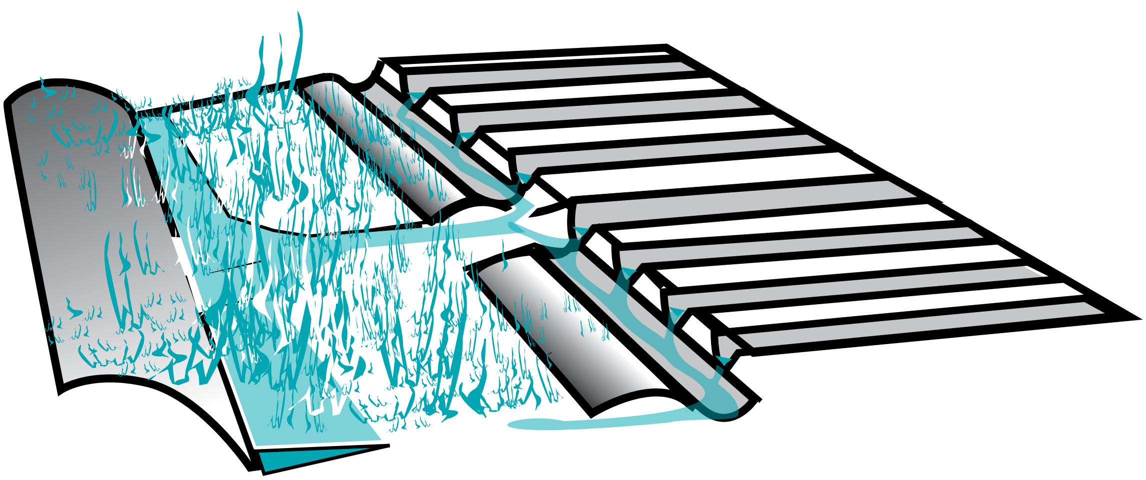
Seed Mix for Native Grass Planting

Seed/Plant	Lbs PLS*/acre	Cost
Leymus triticoides Creeping wildrye 'Luna'	6	$64.00[2] price/PLS/lbs**
Elymus glaucus Blue wildrye	10	$9.00 price/PLS/lbs
Hordeum brachyantherum Meadow barley	8	$14.50 price/PLS/lbs
Total Cost/Acre		**$590**

* PLS = pure live seed
** Price quotes from Pacific Coast Seed, Livermore

Seed Mix for Non-Native Grass Planting

Seed/Plant	Lbs PLS*/acre	Cost
Dactylis glomerata Orchard grass 'Berber'	12	$2.95 Price/PLS/lbs
Agropyron trichophorum Pubescent wheatgrass 'Luna'	16	$2.50 Price/PLS/lbs
Total Cost/Acre		**$75.00**



VEGETATED DITCH/GRASSED WATERWAY Central Valley Installation and Maintenance Costs

Construction/Maintenance Costs

A vegetated ditch can be constructed with common farm implements. Banks are formed with border disks, an angled scraper blade or motor grader. Disc or harrow the waterway bottom to form a seedbed. Seed can be planted either broadcast or drilled, using a vineyard or orchard cover crop drill. Roll the seeded area after planting. Vegetated ditches can be semi permanent installations (5 years or more) or removed and replanted every 3 to 5 years. Effective useful life depends on the amount of accumulated silt and vigor of the vegetation. Vegetated ditches are most effective when used in conjunction with other field-level erosion control practices such as irrigation scheduling, use of polyacrylamide (PAM) or sediment basins. Frequency of sediment removal (maintenance) would be dependent on level of sediment in irrigation tail water.

Grassed waterways are currently being evaluated on Westside San Joaquin Valley farms for their effectiveness in removing pesticides and sediment from irrigation runoff. The ½ mile waterways built for the evaluation will be monitored over several irrigation seasons for their effectiveness under local conditions.

The fallowing charts summarize construction costs for the Stanislaus County grassed waterways. Cost for labor, equipment, and materials (seed) costs, derived from information provided by the owner/managers and with price quotes from a local seed supplier. Maintenance for the sites has not been calculated: anticipated costs are weed control, mowing and cleaning waterways to be performed as needed by the grower.

Costs for Grower Installed Vegetated Ditch

Item	Costs
Equipment and Labor	
Farm equipment (8 hours @ $50/hr)	$400
Farm labor (8 hours @ $20/hr)	$160
Total labor and equipment	**$560**
Materials	
Native grass seed	$590
Non-native grass seed	$75
Total cost (with native grass seed)	**$1,150**
Total cost (with non-native grass seed)	**$635**

Costs for Contractor Installed Vegetated Ditch

Equipment and Labor	
Farm equipment rental*	$1500
Farm equipment transport	$525
Labor	$770
Total labor and equipment	**$2,795**
Materials	
Native grass seed	$590
Non-native grass seed	$75
Total cost (with native grass seed)	**$3,385**
Total cost (with non-native grass seed)	**$2,870**

*Cost for grader, disk, and roller

VEGETATED DITCH/GRASSED WATERWAY Central Valley Installation and Maintenance Costs

Detail of Representative Installation, Operation & Maintenance Costs†

Non-Engineered Grassed Waterways (1,000 Linear Feet) – Central Coast 2003

	Non-Match Labor		Machine Labor		Custom Work				
Operation	Hrs/ 1,000 LF	Cost/ 1,000 LF	Hrs/ 1,000 LF	Cost/ 1,000 LF	Hrs/ 1,000 LF	Cost/ 1,000 LF	Material Cost ($/1,000 LF)‡	Total Cost ($/1,000 LF)¶	Your Cost ($/1,000 LF)
Installation (Year 1):									
Clean Waterway					10	550		550	
Plant Erosion Control Mix	1.50	20	.25	5			17§	41	
Set Up Sprinklers & Irrigate	.6	8	.25	5			40	54	
Subtotal		28		10		550	57	645	
Annual Operation & Maint. (Years 2-5):									
Mow Vegetation (Hand)	4.0	54						54	
Clean Waterway					5	275		275	
Subtotal		54					275 0	329	
Interest on Operating Capital @ 7.4%								6	
Total Costs Per Unit – Year 1							57	980	
Total Costs Per Unit Per Year – Yrs 2-5							0	329	
Total Costs Per Linear Foot – Year 1							**	1	
Total Costs Per Linear Foot – Yrs 2-5							0	**	

From U.C. Cooperative Extension, Central Coast Conservation Practices, Estimated Costs and Potential Benefits for Non-Engineered Grassed Waterways 2003

† Costs are per 1,000 linear feet.
‡ Detail of material costs located in Table 3. Representative Material Costs.
¶ May not sum due to rounding.
§ Includes fuel, lube and repairs.
** Cost is negligible when represented on a linear foot basis.

PAM in Irrigation Water

Polyacrylamide (PAM) is a synthetic water-soluble polymer applied to irrigation water or into furrows prior to irrigation. PAM binds together soil particles suspended in water then settles them to the furrow or ditch bottom. Water-soluble polymers similar to PAM are commonly used in treatment of municipal water supplies, food packaging and as adhesives. Water-soluble polymers were first introduced as soil conditioners in the 1950's. In recent years, new formulations and application techniques have improved the effectiveness of PAM in irrigation water. PAM has been shown to reduce soil erosion by 90-95 percent and improve water infiltration rates by 20-60 percent, according to NRCS and university studies.

Advantages

- Relatively low cost per acre
- High reduction of irrigation-induced erosion and soil loss
- Ease of product application and integration into normal irrigation practices

Disadvantages

- Extra labor or equipment required for application
- Repeated applications can increase cost per acre
- May increase soil infiltration rates in certain soil types beyond need
- Applications must be repeated following cultivations, increasing the cost per acre.

NOTE

In field studies in western Stanislaus County, PAM reduced sediment concentrations in furrow irrigation drain water but was not effective in reducing chlorpyrifos (Lorsban, Lock-On, Govern) insecticide concentrations in PAM-treated drain water. The results suggest that most chlorpyrifos in drain water is not associated with sediment, so sediment reductions have little effect on chlorpyrifos concentrations.

Application Methods

Dry Granular PAM

Dry granular PAM is typically applied using an augured metering system into a supply canal before it hits the furrow, or applied directly in the furrow using what is known as the "patch method". Proper agitation is needed to properly dissolve PAM in the irrigation supply ditch. Lack of agitation results in globules forming and little reduction in furrow erosion. A drop structure in the irrigation ditch can provide turbulence and aid in dissolving granules. The "patch method" involves placing PAM at the head of the furrow; spreading it across 3-5 feet of the furrow to reduce the risk of the PAM becoming buried or washing down with little or no effect.

Liquid PAM

Liquid PAM can be metered and injected directly into an irrigation ditch, furrow, or pipeline. Emulsified PAM (special liquid PAM solutions) can be applied like the granular form into irrigation ditches or furrows using the patch method. Emulsified PAM doesn't require as vigorous mixing as granular but still needs adequate mixing for dissolving. Emulsified PAM is more voluminous than dry forms, but is easier to dissolve and is the only form of PAM to use in sprinklers due to reduced risk of clogging laterals.

Solid Blocks or Cubes

PAM blocks (or cubes) are typically placed in wire baskets in flowing ditches at turbulent points. The blocks slowly dissolve, releasing small amounts of PAM into the water. PAM blocks may not perform as well as liquid or granular PAM in furrow irrigation. PAM blocks have been useful for treating sediment ponds to accelerate water clarification and promote flocculation. PAM blocks can also be used to dose concentrated runoff areas on fields that otherwise cause uncontrolled erosion.

Check with your PAM supplier for application rates to match your soil type and irrigation system.

PAM IN IRRIGATION WATER Central Valley Installation and Maintenance Costs

Cost Estimates for PAM (2007)

Product and Equipment Costs for Dry PAM

Item	Costs per Unit	
	Low	High
Product cost per pound	$3.50	$4
Product cost per acre, per application	$0.875*	$4*
Total product costs per acre, per year	$2.63**	$24**
Application Equipment (Fishfeeder)	$ 300	$ 300

* At a low rate of ¼ lb per acre and a high rate of 1lb per acre
** When applied 3 and 6 times per year, respectively

Estimated Costs of Granular PAM in Irrigated Furrows

Item	Costs per Unit
Material per pound	$ 1.86
Labor per application, per acre*	$ 1.00
Total, per acre, per event	$ 2.86
Total cost, per acre, per year**	$30.74

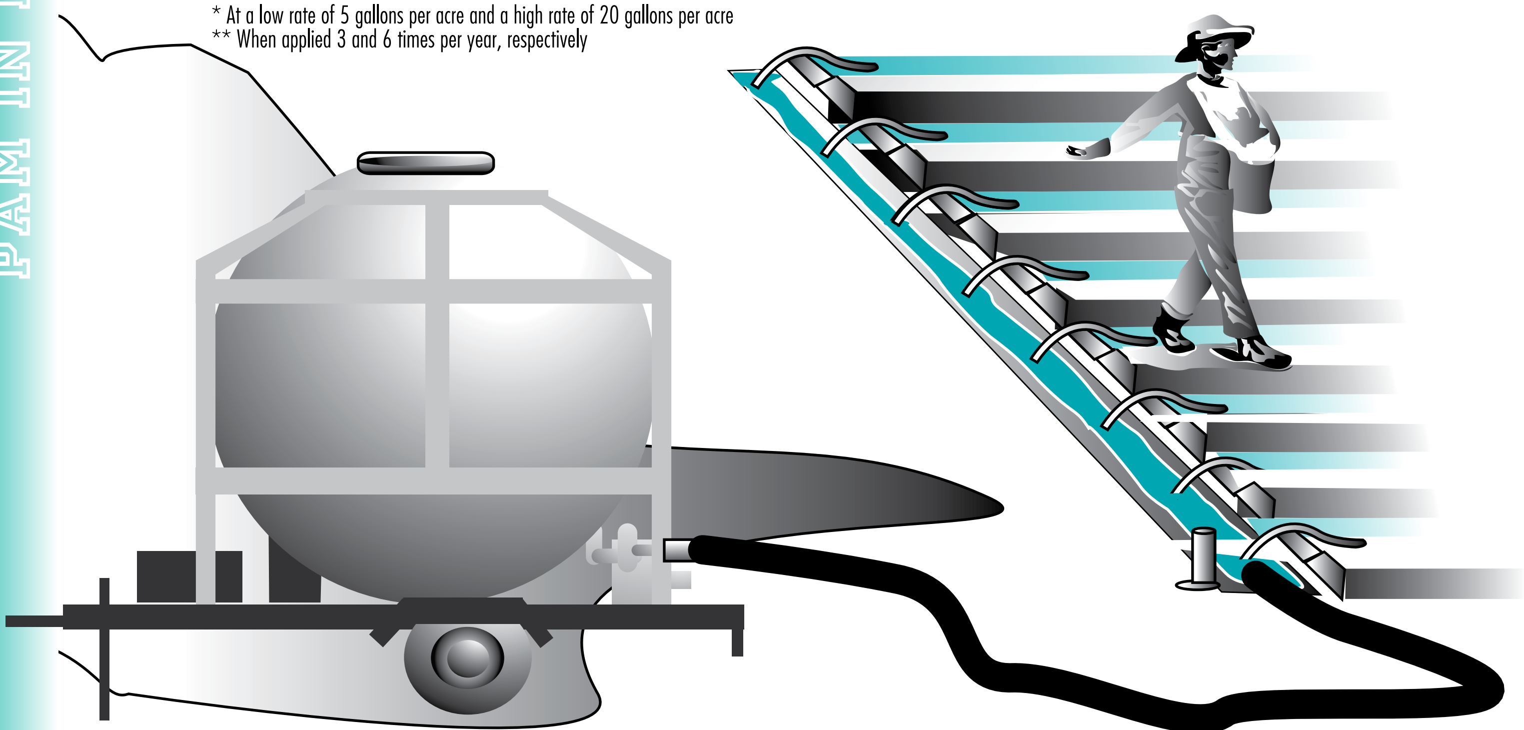
* Granular PAM (with an application rate of 1 lb/A)

** Applied at full rate for intitial irrigation and 3 irrigations following cultivation, then at half rate for 10 other irrigations (9lb/A, 14 events

Product and Equipment Costs for Liquid PAM

Item	Costs per Unit	
	Low	High
Product cost per gallon	$1.35	$1.35
Product cost per acre, per application	$6.75*	$13.50*
Total product costs per acre, per year	$ 20.25**	$81**

* At a low rate of 5 gallons per acre and a high rate of 20 gallons per acre
** When applied 3 and 6 times per year, respectively



Irrigation Scheduling

Irrigation scheduling is the process used by growers and irrigation managers to determine the correct frequency and duration of watering. Irrigation scheduling in simple terms is the knowledge of when to irrigate and how much irrigation water to apply. An effective irrigation schedule helps to maximize profits while minimizing water and energy use.

Weather-based irrigation scheduling can use either historical weather data, or "real-time" weather data. The former relies upon averages, while the latter tracks current conditions. Historical schedules work better with surface and impact sprinkler irrigation systems as high levels of soil moisture storage tend to buffer or smooth out daily differences in weather. Irrigation schedules using "real-time" weather data are recommended for all irrigation systems, but especially for drip/micro irrigation systems. These types of systems only water a portion of the potential root zone and therefore water storage is not as extensive as other types of irrigation.

One of the best ways to develop an irrigation schedule is through the Center for Irrigation Technology's "Wateright," available on-line at http://www.wateright.org. System specific information can be input (emitter numbers and spacing, flow rate, plant and row spacing, type of device, maturity of crop, etc.) and the program will do the calculations needed to develop the proper schedule.

In this booklet, five steps are described for the setup of an irrigation schedule:

1) Select an appropriate historical, and real-time, source for reference evapotranspiration (ET) rates and effective rain suitable to the area.
2) Select the appropriate crop coefficient data.
3) Select a soil texture and root zone depth appropriate for your area and crop.
4) Determine the management allowable depletion (MAD).
5) Select the appropriate irrigation efficiency.

Step 1: Select an appropriate historical, and real-time, source for reference evapotranspiration (ETo) rates and effective rain suitable to the area

The California Irrigation Management Information System (CIMIS) has an established network of weather stations throughout California that monitor real time weather conditions. You can access CIMIS at: http://wwwcimis.water.ca.gov/cimis/welcome.jsp. CIMIS calculates reference evapotranspiration or "ETo" for specific zones in California. Evapotranspiration is the combination of atmospheric evaporation and plant transpiration.

There are 4 CIMIS stations in the central San Joaquin Valley region: Station #92: Kesterson; Station #56: Los Banos; Station #148: Merced; and Station #161: Patterson. Although there is not a station in the center of the Orestimba Creek area, the most representative station appears to be Merced (station #148).

Step 2: Select the appropriate crop coefficient data

Reference ETo is usually determined by the amount of water used by a grass crop at the CIMIS station. Crop coefficients are used to determine water use for your specific crop in relation to its stage of growth. Early season crop coefficients are usually a small percentage of the reference ETo. Later in the season they can match or even exceed reference ETo.

IRRIGATION SCHEDULING Central Valley Installation and Maintenance Costs

Step 3: Select a soil texture and root zone depth appropriate for your area and crop

The Westside San Joaquin (northern region) watershed area generally consists of deep soils, with a range of soil textures from light to heavy. In some areas there are drainage impacted problems that may affect root zone growth. Your knowledge and experience with local crops and soil conditions will be a valuable tool in selecting a soil type and in determining an appropriate root zone for your particular crop.

In Table 1, rooting depth average, represents an average root zone in which 80% of the feeder roots would be contained

See www.curesworks.org for example irrigation scheduling templates. Three soil types were picked for each crop (with the exception of loamy sand for alfalfa, walnuts, and tomatoes, which are generally unsuitable crops for very light soils). These types of schedules can be developed at www.wateright.org.

Step 4: Determine the management allowable depletion (MAD)

Crops have varying ability to extract water from soil. As soils become drier, roots have to work harder to pull water out from soil pores. At a certain point, the plant begins to shut down and growth is slowed. Growers and irrigation system managers usually determine when to irrigate based upon the crop type and the soil's ability to give up its water. This term is commonly referred to as "management allowable depletion" or "MAD."

MAD is the percentage of the total available water which may be safely depleted before moisture stress occurs. Sand, for example, will be able to give up a higher percentage of its water before the plant experiences stress. Your specific soil type and crop will determine the MAD used for your irrigation schedule. Table 2 suggests average MAD percentages for specific crops.

Table 1
Average Root Zone Depths by Crop (approximately 80% of active roots)

		Suggested Orestimba Root Zones
Alfalfa Hay (cut)	4 to 6	5
Almonds	2 to 5	4
Dry Beans	1 to 3	3
Tomatoes	2 to 4	3
Walnuts	5.5 to 8	5

IRRIGATION SCHEDULING Central Valley Installation and Maintenance Costs

Table 2

Average Percentages of Management Allowable Depletions of Soil Moisture by Crop

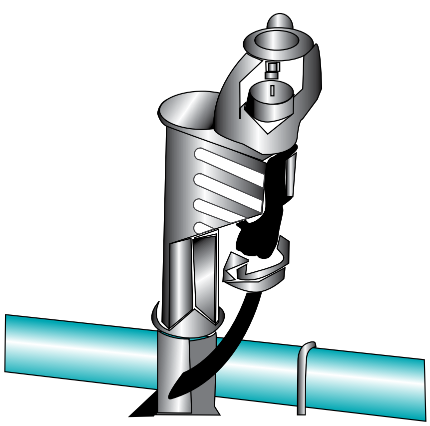
		Suggested Orestimba
Alfalfa	50-55%	50
Deciduous fruit	50%	50
Beans	45%	45
Tomatoes	40%	40

Table 3

Practical potential irrigation efficiencies

Method	Irrigation Efficiency%	Suggested Orestimba
Sprinkler		
Continuous Move	80-90	85
Periodic-move	70-80	75
Portable solid-set	70-80	75
Micro-irrigation		
Drip, microsprinklers	80-90	85
Furrow	70-85	75-80 *
Border	70-85	75 *

* Assumes good management, and a tailwater recovery system that returns water to the same fields managed by that owner. In other words if the tailwater runs off the farmer's field and is no longer in his control, the IE no longer applies.



Step 5: Select the appropriate irrigation efficiency

Irrigation efficiency is usually defined as the amount of water used for the benefit of the crop divided by the gross amount applied. The "gross applied" portion relates to both the timing of the irrigation and how uniformly the water is applied. Irrigation systems that are engineered and managed properly have a high percentage of the applied water used to benefit the crop. While furrow and border (flood irrigation) systems can have good timing and fairly high uniformity, the efficiency of these systems are less than well designed drip/micro irrigation systems. Table 3 presents these efficiencies. If your system has an 85% efficiency you will need to apply enough water so that 85% of the amount applied meets your crop water needs.

References

Wateright. www.wateright.org

CIMIS. http://wwwcimis.water.ca.gov/cimis/welcome.jsp

Snyder, R.L., M. Orang, K. Bali and S. Eching. 2005. Basic Irrigation Scheduling (BIS). Regents of the University of California.

Snyder, MS Excel Scheduling Program. http://biomet.ucdavis.edu/

Hanson, B., L. Schwankl and A. Fulton. 1999. Scheduling Irrigations, When and How Much Water to Apply. Regents of the University of California, Division of Agriculture and Natural Resources. 202 p.

Hansen, B.R., and W. Bowers. 1994. An Analysis of Mobile Irrigation System Evaluation Data. Final Report to the California State Department of Water Resources (Division of Planning).

Irrigation Tailwater Return Systems

Tailwater return systems recover, control and reuse field-applied irrigation water or storm flows. Water flowing off the low end of a field is collected in a sump and reapplied on the same or adjacent fields by gravity flow or use of a booster pumps. Components of a tailwater return system: drainage ditches, water control structures, sediment basins, retention ponds (pits) and pumps with return piping that delivers runoff to the head of the field.

Advantages

- Eliminates agricultural drainage
- Eliminates sediment leaving field
- Conserves irrigation water
- Potentially recycles all tailwater
- Preserves downstream water quality
- Reduces weed seeds, insects in downsteam water supply
- Recirculates silt (deposits on field)
- Can eliminate need for additional management practices to meet off farm sediment standards
- Can reduce groundwater pumping costs
- Higher irrigation efficiency
- Return system may not reuse all tailwater; still potential increase in irrigation efficiency of 25-30%.
- Improved nutrient control/management

Disadvantages

- High cost to construct
- More management needed
- Potentially higher labor cost
- May increase salt deposition
- Takes land out of production
- May increase pumping costs
- Recirculates silt reducing soil intake rate

Installation/Maintenance Costs

Personalized estimates for tailwater return systems are available from the Stanislaus County Natural Resource Conservation Service (NRCS) office or a competent consultant with requisite design experience.

Booster pump, aluminum pipe, materials	$300-500/acre
Annual operation and maintenance cost range	$28-$60/acre

Tailwater Return Systems in the Orestimba Creek Area

In 2005, Summers Engineering of Hanford, California prepared a cost estimate for a grant proposal to design and install a tailwater return system in the Orestimba Creek drainage. The conceptual system would collect water from approximately 700 acres of irrigated alfalfa, walnut, and dry bean fields. The system was designed with a tailwater reservoir capable of collecting 600 acre-feet of runoff. Although the proposal was not funded, the estimate provided a baseline for what a similar system would cost (see below).

*Cost for a Contractor Designed and Installed Tailwater Return System**

Item	Costs
Installation	
Design	$ 37,470
Construction	$280,500
Total cost	**$317,970**
Annual pumping costs	$ 6,000

*600 acre feet @$10/AF for electricity.

IRRIGATION TAILWATER RETURN SYSTEMS

IRRIGATION TAILWATER RETURN SYSTEMS Central Valley Installation and Maintenance Costs

Wildlife-Friendly Tailwater Return Pond

In 2002, the Yolo County Resource Conservation District compiled a handbook containing practical information for farmers wishing to provide wildlife habitat on their land. Included in the handbook was a design for a tailwater pond and return system. Design costs include pond banks planted with native plants to improve water quality, habitat, and esthetics. Low and high cost estimates (1999 dollars), based on pond size, are shown below.

Cost Range for Tailwater Return System

Item	Cost	
Installation	Low (2,500yd^3)	High (7,500yd^3)
Pond	$3,730	$11,525
Return system	$9,850	$16,030
Vegetation establishment	$1,120	$ 2,840
Total	$14,700	$30,401
Annual Maintenance	$ 203	$ 618

Water Use Efficiency Tailwater Return Pond

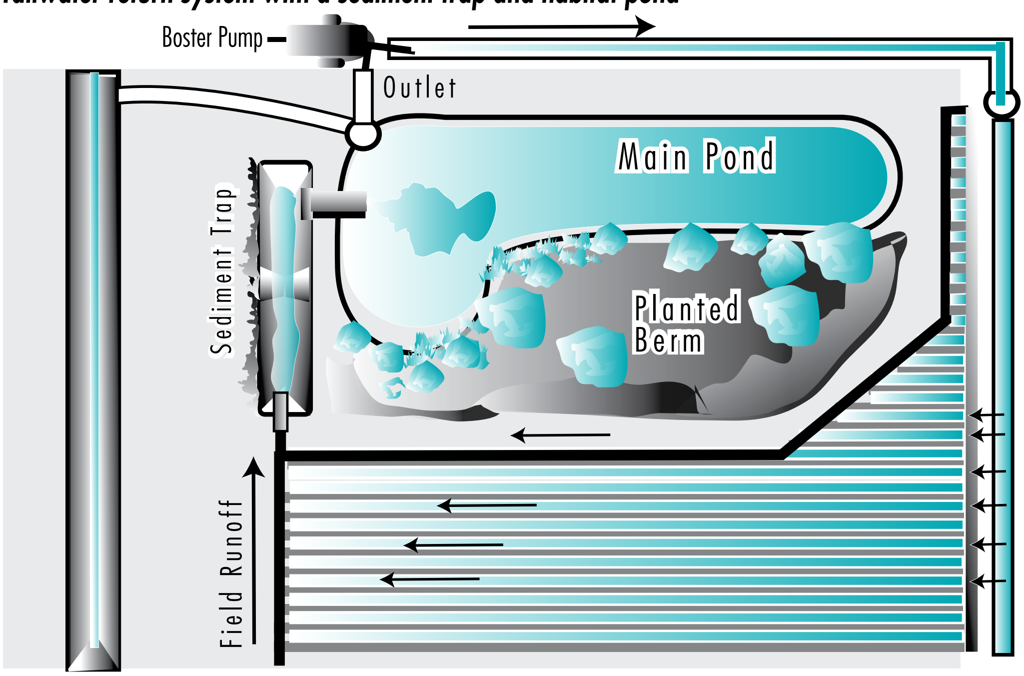
The Yolo County Resource Conservation District recently established five tailwater ponds in their area, all installed by local landowners. Costs depended on pond size, which ranged from 1.5 to 4 acre-ft capacity, pump size, type of return system and whether or not native vegetation was planted. (Yolo County Resource Conservation District. 2001. CALFED Water Use Efficiency Program Final Report. Yolo County RCD Pilot Program.)

Cost Range for Installation of Tailwater Return System

Item	Cost	
	Low (2,500yd^3)	High (7,500yd^3)
Pond and inlet/outlet structures	$ 4,000	$12,000
Return system with 1800' of pipe	$10,000	$16,000
Addition of native vegetation*	$ 1,000	$ 3,000

*Includes material, labor, and irrigation system

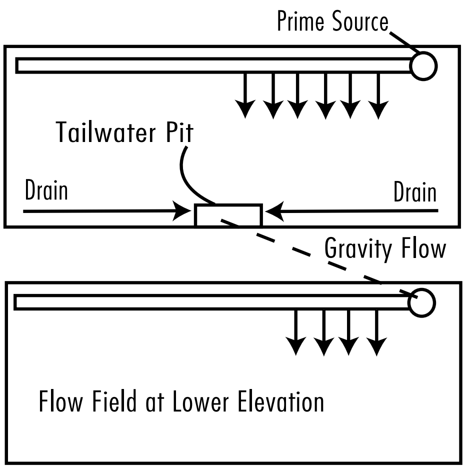
Tailwater return system with a sediment trap and habitat pond



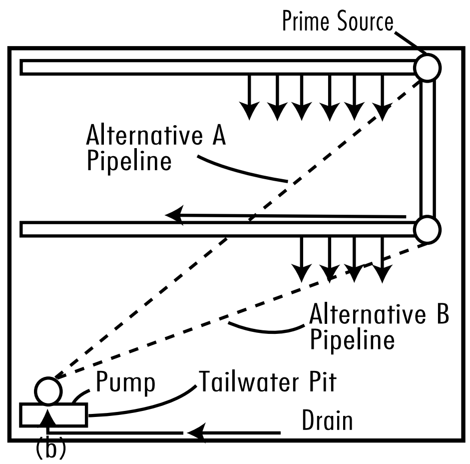
BMP Handbook

IRRIGATION TAILWATER RETURN SYSTEMS Central Valley Installation and Maintenance Costs

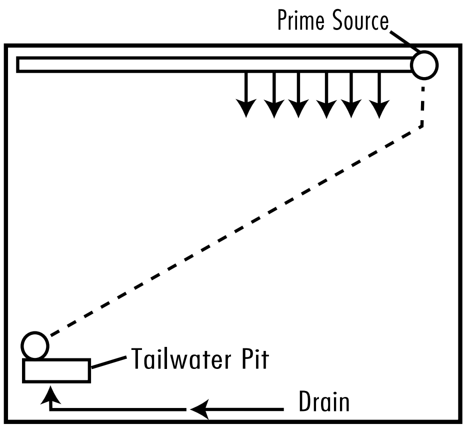
(a) sequential reuse to irrigate lower-lying lands



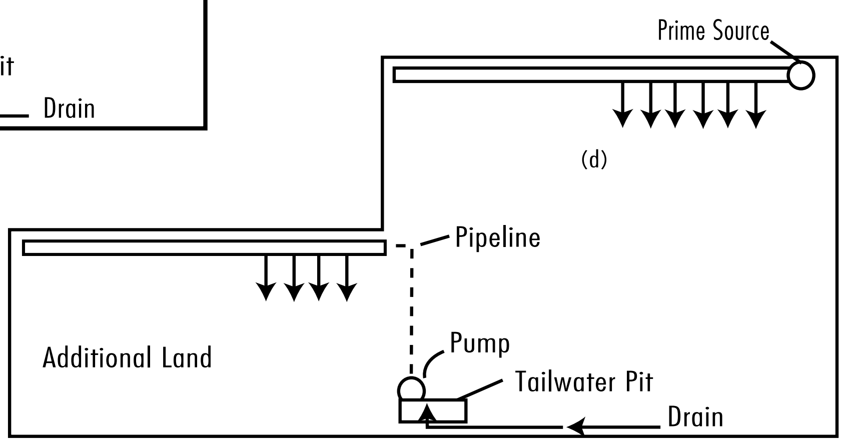
(c) return reuse system to the highest point in the same field



(b) alternative return reuse systems for sequential fields



(d) return reuse system to irrigate new additional lands



RESOURCE GUIDE

Sources of Best Management Practice Information in Stanislaus County

Agency	*Program Description*	*Publications*	*Outreach*
Natural Resources Conservation Service Modesto Service Center 3800 Cornucopia Way Ste. E Modesto, CA 95358-9494 (209) 491-9320 (209) 491-9331 fax	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 Stanislaus County 3800 Cornucopia Way Modesto, CA 95358 (209) 525-6800 (209) 525-6840	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 (Almonds, Peaches, Tomatoes, Walnuts, Melons) The Almond Board of California 1150 Ninth St., Ste. 1500 Modesto, CA 95354 (209) 549-8262 (209) 549-8267 fax **www.almondboard.com** **www.almondsarein.com** California Melon Research Advisory Board 531-D North Alta Ave. Dinuba, CA 93618 (559) 591-0435 (559) 591-5744	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. • 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.

RESOURCE GUIDE

RESOURCE GUIDE

Sources of Best Management Practice Information in Stanislaus County

Agency	Program Description	Publications	Outreach
Commodity Groups (Almonds, Melons, Tomatoes, Walnuts) California Tomato Commission 1625 E. Shaw Ave., Ste. 22 Fresno, CA 93710 (559) 230-0116 (559) 230-0635 **www.tomato.org** Processing Tomato Advisory Board 1450 Halyard Dr., Ste. 11 West Sacramento, CA 95798 (916) 371-3470 (916) 371-3476 **www.ptab.org** California Walnut Commission 1540 River Park Dr., Ste. 203 Sacramento, CA 95815 (916) 646-3807 (916) 923-2548 **www.walnut.org**	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.
Stanislaus County Agricultural Commissioner Dennis Gudgel 3800 Cornucopia Way, Ste. B Modesto, CA 95358 (209) 525-4730 (209) 525-4790 **agcom50@mail.co.stanislaus.ca.us**	County regulatory enforcement agency for pesticide use and handling.	Stanislaus 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 taken to receive a Pesticide Applicator Permit, a license needed to purchase and apply pesticides.	Stanislaus County Agricultural Commissioner holds periodic continuing education meetings for growers and Pest Control Advisors (PCAs). These meetings cover regulations, production practices and various subjects related to proper use and handling of pesticides.
Coalition for Urban/ Rural Environmental Stewardship CURES Parry Klassen 531-D North Alta Ave. Dinuba, CA 93618 (559) 591-1995 **www.curesworks.org**	A non-profit education organization focusing on promoting pesticide and nutrient BMPs; also develops and coordinates research projects on BMPs.	CURES produces booklets 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 GUIDE

Sources of Best Management Practice Information in Stanislaus County

Agency	Program Description	Publications	Outreach
Resource Conservations Districts West Stanislaus Resource Conservation District 20 N. El Circulo Patterson, CA 95363 (209) 892-3026 (209) 892-5136 **www.carcd.org/wisp/ weststanislaus/index.htm**	Grower managed entity based in Stanislaus County that coordinates projects and programs related to resource management.		RCD organizes periodic educational workshops and meetings on subjects related to resource conservation.
Farm Input Suppliers	Private firms that sell farm inputs and provide information through licensed Pest Control Advisors (PCAs)	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.	Staff PCAs have frequent personal contact with landowners to advise on pesticide recommendations
Natural Resources Conservation Service (NRCS)- EQIP Program Modesto Service Center 3800 Cornucopia Way Ste. E Modesto, CA 95358-9494 (209) 491-9320 (209) 491-9331 fax	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 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.		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 address the resource concerns. The practices are subject to NRCS technical standards adapted for local conditions. The local conservation district approves the plan.
California Water Institute California State University, Fresno 6014 N. Cedar Fresno, CA 93710 (559) 298-6072 (559) 298-3576 fax **www.californiawater.org**	Established through Proposition 13 funding, CWI is an academic center of excellence for research, education and policy analysis of issues involving water resources.	CWI and its sister organizations at California State University, Fresno have created and distributed materials and online resources regarding irrigation scheduling and planning. These materials have included methods and tools for managing irrigation practices so they are most effective and efficient.	CWI and its sister organizations at Fresno State have also organized numerous seminars educating farmers and irrigation technicians on irrigation management practices and how they can be done in a more efficient way to save both water and energy.
Westside San Joaquin River Watershed Coalition Joe McGahan, Watershed Coordinator 559-582-9237 **jmcgahan@summerseng.com**	Formed to assist growers in complying with the Irrigated Lands Regulatory Program of the Central Valley Regional Water Quality Control Board.	Quarterly newsletter providing coalition updates.	Organizes grower educational meetings that provide updates on water monitoring results and potential management practices to address identified problems. Meetings often held in conjunction with water districts, county agricultural commissioners and others.

Resource Guide

Sources of Best Management Practice Information in Stanislaus County

Agency	Program Description	Publications	Outreach
BMP Suppliers PAM Western Farm Service Fred Strauss 35100 S. Hwy. 33 Vernalis, CA 95385 209-835-7597 209-541-7562 cell	PAM: A product applied to irrigation water for the reduction of sediment transport in irrigation drain water.		
Land Guard OP Orica Ltd. Rachelle Antinetti Regional Sales Manager – Land Guard 209-679-4449 **rachelle.antinetti@orica.com**	Land Guard OP is an enzyme based technology that when added to farm drainage waters, can speed the degradation of organophosphate pesticides (enzymes for other pesticides in development).		

Contacts

SPONSORS

Sponsors

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Cures
Coalition for Urban/Rural Environmental Stewardship
www.curesworks.org

California Water Boards
State Water Resources Control Board
Regional Water Quality Control Boards

San Luis & Delta-Mendota Water Authority

BMP Handbook

Drip / Micro Sprinkler Irrigation Systems

Installation and Maintenance Costs

Drip/micro sprinkler systems use an engineered network of plastic components to precisely deliver water to each plant. Drip/micro sprinkler systems are designed so application rate is less than the soil infiltration rate, minimizing or eliminating irrigation water runoff. With drip/micro sprinklers, frequent irrigations of low volumes of water are applied to a portion of the available surface or subsurface area. The volume of soil wetted by drip/micro sprinkler systems varies from 10% to over 80% depending on crop type, soil type, cost of system, type of emitter, emitter flow rate, and other factors.

Drip/micro sprinkler systems are custom designed and engineered. The system designer takes into consideration soil, crop water requirements, plant spacing, water source and quality, field shape, elevation changes, electrical or power supply availability and locations, cultivation and farming practices. Also considered is cost of plastic pipe and hardware, the quality of components (both initial, and long term), the owner's ability to manage and maintain a system effectively and the intended lifespan of the system.

A system application rate must be high enough to meet daily plant water requirements in an 18-hour (or less) period of run time (to take advantage of off-peak time-of-use energy rates). Orchard root diseases are minimized when run time is limited to 24 to 48 hours. Application rates of drip/micro systems vary from 0.02 in/hr to 0.10 in/hr.

Maintenance and Management

Drip/micro sprinkler systems are typically designed to achieve a system distribution uniformity (DU) of 85% to 95%. DU is a measure of how uniformly water is spread throughout a field. DU values decline with time due to clogging of emitters, emitter wear, increased pressure differences between emitters, and other factors. A drop in DU results in increased operating hours to accommodate the driest field areas. Increased operating time, assuming accurate irrigation scheduling, can result in over watering the wettest portions of a field. Deep percolation of excess water, and any nutrients, salts, or mobile components in the irrigation water, will degrade in transport, runoff to surface drains or leach to aquifers.

Costs for Grower/Contractor Installed Drip or Micro Irrigation System

Item	Costs per Acre	
	Low	High
Installation and maintenance for the life of the system*	$800	$1,800

* Includes cost of new pump at $100/A

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Typical Irrigation system layout (USDA-NRDA, 1997a; Turner, 1980)