SEPTEMBER 2019

SACRAMENTO VALLEY
WATER QUALITY COALITION

DRAFT Surface Water Quality Management Plan: *Hyalella azteca* Toxicity in Ulatis Creek

prepared by

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1 Introduction and Background

The purpose of this Management Plan is to document the management practices implementation and performance goals and schedule to address potential agricultural causes of sediment toxicity to a freshwater amphipod (*Hyalella azteca*) observed in Sacramento Valley Water Quality Coalition (Coalition) Irrigated Lands Regulatory Program (ILRP) monitoring in Ulatis Creek. The elements included in this Management Plan conform to the Coalition's Waste Discharge Requirements (WDR), Order No. R5-2014-0030-05 (as amended by Order R5-2019-0001), issued under the ILRP. The need for performance goals was prompted by two exceedances of the ILRP trigger limit for *Hyalella* sediment toxicity observed during April 2018 and April 2019 in Ulatis Creek. The relevant conclusions established related to these observed exceedances are as follows:

- A review of California Department of Pesticide Regulation (CDPR) Pesticide Use Reporting (PUR) data for agricultural uses in the Cache Slough drainage for a period of two months prior to the observed toxicity exceedances (04/17/2018 and 04/18/2019) showed applications of pyrethroid pesticides known to cause toxicity to *Hyalella* (see **Table A1** and **Table A3**). Similarly, a review of PUR data for non-agricultural uses across Solano County also showed applications of pyrethroid pesticides during the two months leading up to the two observed *Hyalella* sediment toxicity exceedances (see **Table A2** and **Table A4**).

- Based on the review of contemporaneous sediment pesticide analyses associated with the two observed *Hyalella* toxicity exceedances, no individual pyrethroid or collection of pyrethroids were identified as the potential cause of the *Hyalella* sediment toxicity observed in April 2018 when comparing detected pesticides concentrations to a relevant ecotoxicology benchmark for the freshwater amphipod (Amweg et al., 2005). Sediment pesticide analyses associated with the April 2019 *Hyalella* sediment toxicity exceedance indicate that bifenthrin and lambda-cyhalothrin were present in the sediment at concentrations sufficient to cause the observed toxicity to *Hyalella* (see **Table A5**).

- A review of antecedent precipitation data for the Ulatis Creek monitoring site show that the observed April 2018 sediment toxicity exceedance was preceded by a rainfall event that could have produced runoff in the Cache Slough drainage. Approximately 0.28 inches of rain were recorded on the day prior to the April 17, 2018, monitoring event. There was approximately 0.1 inches of antecedent precipitation recorded three days before the April 18, 2019, sediment toxicity exceedance and an additional 0.2 inches of rain recorded during the preceding 18 days. It is unlikely that much, if any, storm runoff entered Ulatis Creek in the three weeks leading up to the April 18, 2019, sediment toxicity exceedance (see **Table A6**).

- As a means to avoid future sediment toxicity to *Hyalella* potentially caused by the activities of irrigated agriculture in the Cache Slough drainage and represented drainages, Dixon/Solano RCD Water Quality Coalition staff (Coalition Staff) will focus on targeted outreach, education and identifying additional practices from growers during the first 18 months of Management Plan implementation. Growers will maintain their current high levels of management practice implementation to control or reduce the risk of discharges of pyrethroids to surface waters.
- Leading up to the Coalition's next Farm Evaluation collection for the 2020 Crop Year, the Coalition Staff will utilize the Coalition's new online data management system to track additional specific (1) pesticide application practices, (2) irrigation practices for managing sediment and erosion, and (3) cultural practices to manage sediment and erosion employed by those growers who apply pyrethroids. The practices included in this targeted survey information will be identified and reviewed with growers and integrated into 2020 Crop Year reporting and to update the Dixon/Solano RCD Water Quality Coalition's *Pyrethroid Facts and Recommended Practices* (see **Appendix D**).
- Based on evaluations of reported pesticide applications by irrigated agriculture, two pyrethroid pesticides and four crops were identified as having the highest use within the Cache Slough represented drainages in the two months prior to the observed toxicity exceedances. The pyrethroid pesticides identified are bifenthrin and lambda-cyhalothrin. The specific crops identified are alfalfa, tomato, barley, and pear (see **Table A1** and **Table A3**).

The results of the April 2018 and April 2019 *Hyalella* sediment toxicity tests did not meet the TIE criterion of ≥ 50% reduction in endpoint (*Hyalella* survival as compared to the control sample) and thus, TIEs were not performed for these two samples. However, both *Hyalella* sediment toxicity tests showed statistically significant toxicity and < 80% organism survival as compared to controls and thus, the Coalition was required to analyze the sediment collected during each monitoring event for pyrethroids[1], chlorpyrifos, and total organic carbon.

The Ulatis Creek monitoring location (Ulatis Creek at Brown Road (UCBRD)) is in the Cache Slough Drainage in the Solano Subwatershed. The UCBRD monitoring location is currently used by the Coalition as a representative monitoring location for the ILRP. The Cache Slough drainage represents the drainages of Putah Creek South, Southwest Yolo Bypass, and the Sacramento River drainage in the Solano Subwatershed (Sacramento River – Solano).

The implementation goals presented in this document are intended to maintain management practices that minimize pyrethroid discharges and prevent sediment

[1] Ulatis Creek sediment samples were analyzed for the following pyrethroids: bifenthrin, cyfluthrin, cypermethrin, deltamethrin, esfenvalerate, fenpropathrin, lambda-cyhalothrin, and permethrin.

toxicity to sensitive invertebrates due to agricultural uses of pyrethroids in the Cache Slough, Putah Creek South, Southwest Yolo Bypass, and Sacramento River – Solano drainages. The geographic scope for the implementation of these practices are summarized in **Table 1**.

Table 1: Summary of Scope of Management Plan Implementation for Toxicity to *Hyalella azteca*.

Management Plan Category (PRIORITY)	Toxicity (HIGH)
Subwatershed	Solano
Representative Water Body	Ulatis Creek
Represented Drainages	Cache Slough, Putah Creek South, Southwest Yolo Bypass, and Sacramento River - Solano
Analytes of Concern	Sediment toxicity due to pyrethroid pesticides, including: bifenthrin and lambda-cyhalothrin
Crops Identified in PUR Data Review	Alfalfa, tomato, barley, pear
Season	Irrigation Season (April – October)

1.1 CONSTITUENT OF CONCERN (COC)

Based on the contemporaneous sediment pesticide analyses associated with the two observed *Hyalella* sediment toxicity exceedances, detected pyrethroid pesticides (bifenthrin, cyfluthrin, cypermethrin, esfenvalerate, lambda-cyhalothrin, and permethrin) in the Ulatis Creek sediment sample collected on April 17, 2018, were measured at concentrations insufficient to cause the observed toxicity to *Hyalella*. Additionally, no chlorpyrifos was detected in the sample. Both pyrethroids and chlorpyrifos were analyzed because of their toxicity to sensitive invertebrates and their potential for additive toxicity effects. With respect to the second observed toxicity exceedance, pyrethroid pesticides (bifenthrin and lambda-cyhalothrin) were measured in the Ulatis Creek sediment sample collected on April 18, 2019, at concentrations sufficient to result in additive toxicity that could cause the observed toxicity to *Hyalella*. Again, no chlorpyrifos was detected in this sediment sample (see **Table A5**).

As a class of pesticides, pyrethroid insecticides are used to kill insects, including mosquitos. Pyrethroids are synthetic derivatives of pyrethrins produced by the flowers of pyrethrums, which includes the genus *Chrysanthemum*. Pyrethrum flowers are a natural insect repellent. Pyrethroids have a high tendency to attach to fine soil particles and tend to be transported in irrigation tailwater, storm runoff, and/or through application drift or overspray to non-target areas. They show varying persistence in the environment depending on their exposure to air and sunlight. Generally, pyrethroid half-life in soils ranges from 1 to 2 months, and in aquatic sediments from months to years. Pyrethroids are very toxic to sensitive invertebrates, such as *Hyalella azteca*.

Because *Hyalella azteca*, a freshwater amphipod belonging to the family Hyalellidae, is used by the ILRP as a test organism to evaluate acute toxicity impacts to sensitive invertebrates due to exposure to pollutants in the sediments of receiving waters, it is appropriate to emphasize outreach and education and management practices related to pyrethroid applications and sediment and erosion control practices in Cache Slough and the represented drainages. An elevated focus on pyrethroid applications will provide an added precautionary measure to the Solano Subwatershed's ongoing outreach and education activities.

PUR data show that the observed toxicity exceedances were associated in time with both agricultural and non-agricultural applications of pyrethroids. Due to the way pesticide applications by irrigated agriculture are required to be reported to the Solano County Agricultural Commissioner (including application date and location information), it is possible to determine where and when pyrethroid pesticides were applied by irrigated agriculture in Cache Slough and the represented drainages. In contrast, licensed non-agricultural applications[2] of pesticides are not required to be reported with associated date and location information, leaving these applications traceable only to the month and county of application (see **Table A2** and **Table A4**). Additionally, a variety of pesticide applications are unreported and unknown, many of which occur in urban areas. These unreported and unknown applications are made by the user groups shown in **Table 2**.

Table 2: Pesticide User Groups that Generally Do Not Report Pesticide Use.

Pesticide User Groups[(1)]
Residents who apply pesticides to their own homes or landscapes
Some maintenance gardeners
Pet groomers/kennels
Employees applying incidental treatments at commercial businesses/buildings
Employees applying incidental treatments at institutional facilities
Employees applying incidental treatments at industrial (factories and warehouses) facilities.
The United States Department of Defense

1. Taken from Kreidich et al. (2005).

The use of pyrethroid-containing products by the general public, such as those user groups listed in **Table 2**, has been identified by CDPR as a concern due to the number of outdoor and indoor products in use and their associated toxicity to sensitive aquatic species. Lambda-cyhalothrin, permethrin, deltamethrin, and bifenthrin are common active ingredients in outdoor pest control products (Budd and Peters, 2018). Although bifenthrin is identified in fewer products than other pyrethroids, it is the most commonly detected insecticide in Northern California ambient waters with a detection frequency of 83%, followed by permethrin at 11% (Ensmiger, 2016). Pyrethroids are also contained in insecticides used for indoor pest control, such as aerosol sprays, fogger products, and

[2] Non-agricultural pesticides applications reported to the California Department of Pesticide Regulation as monthly summary records include those by Licensed Structural Pest Control Operators, Licensed Landscape Pest Control Professionals, and Licensed Public Agency Pest Control Operators.

direct application flea control products. A survey of indoor products sold between 2012 and 2016 found that the average sales of cypermethrin-containing products was an order of magnitude greater than the sale of products containing the second most prevalent active ingredient, deltamethrin. Bifenthrin, permethrin, and lambda-cyhalothrin ranked third, fourth, and eighth, respectively, in the same indoor pesticide products sales evaluation (Budd and Peters, 2018). Additionally, permethrin, deltamethrin, and cypermethrin are contained in flea/tick medicines used at home by pet owners and applied to humans for the treatment of scabies and lice. These same three pyrethroid insecticides also are applied topically and to clothing/netting to repel mosquitoes (Chrustek et al. 2018). In short, the use of pyrethroid-containing pesticides by non-licensed user groups in urban areas is significant but cannot be quantified nor compared to uses by professional applicators at this time due to lack of available information.

1.2 TRIGGER LIMITS

The Coalition's Order requires that Members comply with all adopted water quality objectives (WQOs) and established federal water quality criteria applicable to their discharges. The Order specifies the use of applicable numeric and narrative WQOs in the *Water Quality Control Plan for the Sacramento River and San Joaquin River Basins* (Basin Plan), and the criteria in USEPA's 1993 National Toxics Rule (NTR) and 2000 California Toxics Rule (CTR), which constitute numeric WQOs when combined with the Basin Plan's beneficial use designations. The numeric objectives from these sources are compiled in Table 5 of the Order's Monitoring and Reporting Program (MRP) (see Attachment B of Order No. R5-2014-0030-05).

The Order's MRP establishes management plan trigger limits that are equivalent to the applicable Basin Plan numeric WQOs. The Coalition is required to prepare exceedance reports if surface water monitoring results show exceedances of adopted numeric WQOs or trigger limits that are based on interpretations of narrative WQOs. In locations where management plan trigger limits are exceeded, Surface Water Quality Management Plans must be developed that will form the basis for reporting which steps have been taken by growers to achieve compliance with numeric and narrative WQOs.

The ILRP trigger limit (based on the Basin Plan's narrative toxicity objective) for sediment toxicity to the freshwater amphipod known as Mexican scud (*Hyalella azteca*) is statistically significant toxicity and < 80% organism survival as compared to the control (i.e., the sediment sample showing toxicity must show a Percent Effect that is > 20%[3]). This Basin Plan's narrative toxicity objective exists to control toxic substances in concentrations that produce detrimental responses in human, plant, animal, or aquatic life. The Coalition compares all *Hyalella* toxicity testing data to this ILRP trigger limit.

[3] A 20% effect threshold is recommended by the Surface Water Ambient Monitoring Program (SWAMP) to evaluate toxicity in sediment, per the Central Valley Water Board's approval letter, dated 11 February 2015, to the Coalition for completion of the Cosumnes River *Hyalella* Toxicity Management Plan.

1.3 MANAGEMENT PLAN BOUNDARIES

As described above, the geographic boundaries of the Management Plan for Ulatis Creek include the representative Cache Slough drainage, as well as the represented drainages of Putah Creek, Southwest Yolo Bypass, and Sacramento River – Solano. All four drainages and the Coalition monitoring site (UCBRD) on Ulatis Creek are shown in **Figure 1**.

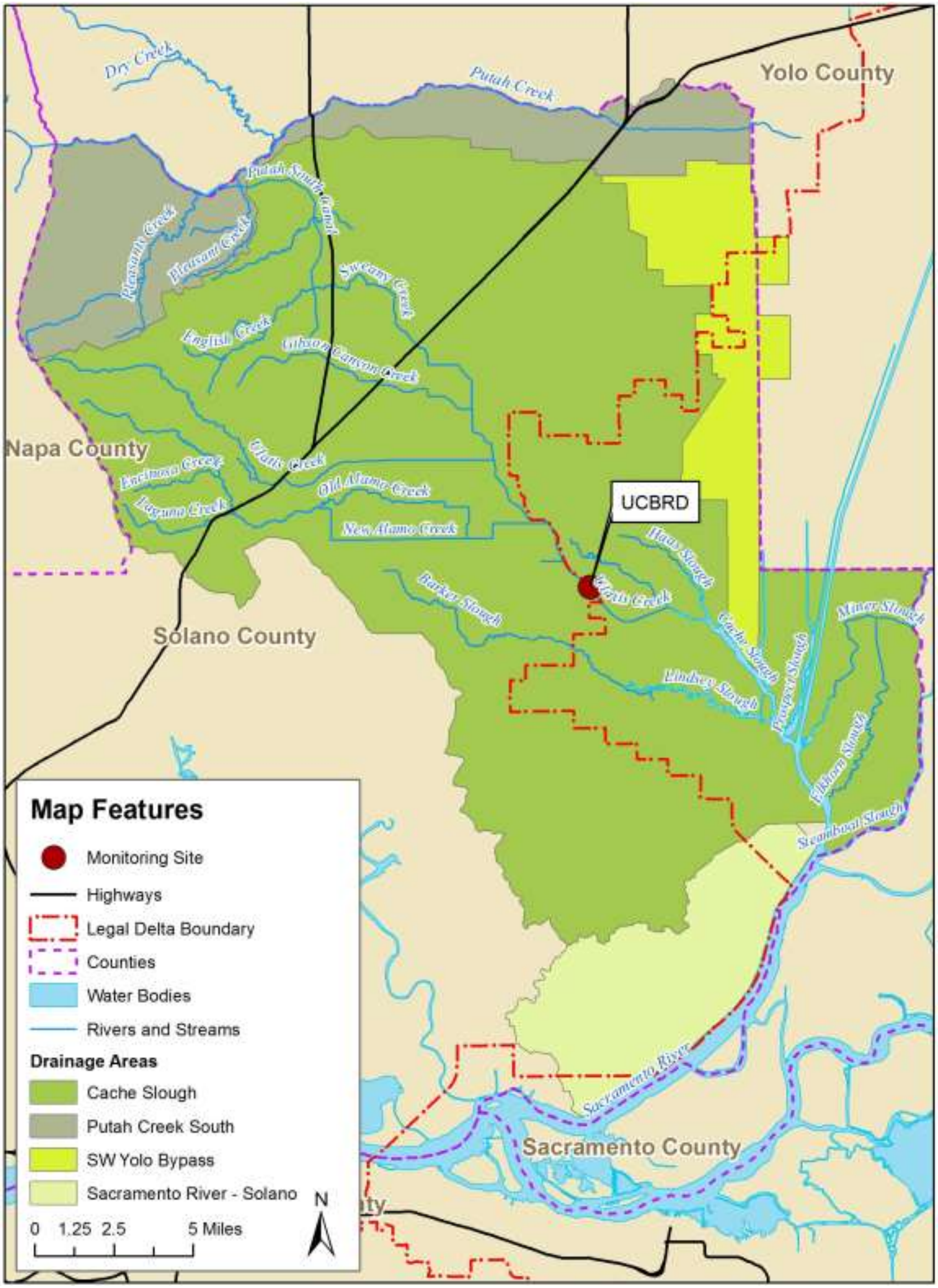

Figure 1: Management Plan Boundaries for the Cache Slough Represented Drainages.

2 Physical Setting and Information

2.1 LAND USE CHARACTERIZATION AND BENEFICIAL USES

The boundaries, crop categories, and land uses within each of the four drainages considered by this Management Plan are shown in **Figure 2**. The boundaries and land use characteristics for the Cache Slough drainage and the three represented drainages are also listed in **Table 3**.

Designated beneficial uses that are relevant to the implementation of the ILRP are municipal and domestic water supply (MUN), agricultural water supply (AGR), contact recreation (REC-1), and aquatic life uses including freshwater habitat, migration, and spawning for cold water and warm water species (WARM, COLD). Specific beneficial uses have been designated in the Central Valley Basin Plan only for the Sacramento River and direct perennial tributaries to the Sacramento River in this subwatershed.

Table 3: Land Use Characteristics for Cache Slough Drainage and Represented Drainages.

Drainage	Drainage Acres[1]	Irrigated Acres (non-rice)[1][2]	% Irrigated Acres (non-rice)[1][2]	Major Crop Types[3]
Cache Slough	236,346	86,108	36.4	Pasture, Alfalfa, Almonds, Sunflower, Tomato (processing), Walnuts, Irrigated Pasture, Triticale, Safflower, Wheat
Putah Creek South	38,230	13,684	35.8	Tomato (processing), Walnuts, Sunflower, Alfalfa, Almonds
Southwest Yolo Bypass	22,658	13,839	61.1	Pasture, Alfalfa, Almonds, Irrigated Pasture, Sunflower
Sacramento River – Solano	24,836	247	1.0	Alfalfa, Pasture, Wine Grapes

1. California Department of Water Resources (DWR). 2013. Land Use Surveys by County. Vector data available at http://www.water.ca.gov/landwateruse/lusrvymain.cfm. Accessed September 2014.

2. California Department of Pesticide Regulation (DPR). 2013. Pesticide Use Reporting (PUR) Field Boundaries Land Use Data. GIS file. Accessed November 2013 by county from County Agricultural Commissioner.

3. Crop type information from 2017 Farm Evaluation Survey results. Major crops listed collectively represent approximately 75% or greater of total planted acreage in each drainage.

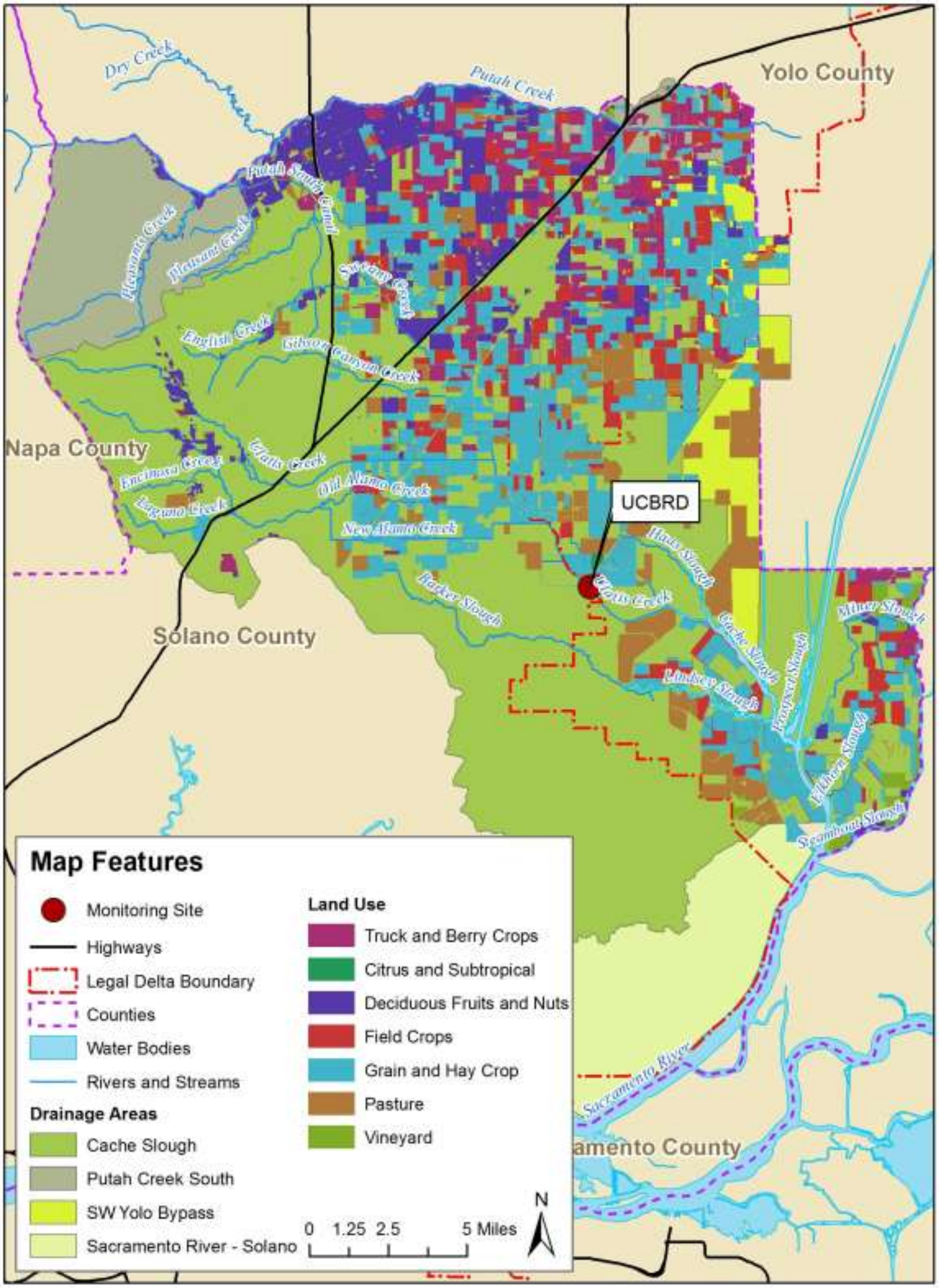

Figure 2: Land Use Characterization of the Cache Slough Represented Drainages.

The beneficial uses for Cache Slough and each of the represented drainages shown in **Table 4** are taken from Table II-1 of the Basin Plan. Various water bodies in the Cache Slough drainage are identified in the Basin Plan (Appendix 42) as Delta Waterways. Those reaches of these Delta Waterways that reside in the "Legal" Delta are assigned the beneficial uses designated for the Sacramento-San Joaquin Delta. Beneficial uses for the Putah Creek South drainage are those designated for the Putah Creek: Lake Berryessa to Yolo Bypass surface water body segment; beneficial uses for the Southwest Yolo Bypass drainage are those designated for the Yolo Bypass surface water body; and the beneficial uses for the Sacramento River drainage in the Solano Subwatershed are those designated for the Sacramento-San Joaquin Delta.

Table 4: Beneficial Uses Designated for Cache Slough and Represented Drainages.

Beneficial Uses for Surface Water as Defined in Basin Plan	Cache Slough(1)(2)	Putah Creek South(3)	SW Yolo Bypass(4)	Sac River – Solano(5)
Municipal and Domestic Supply (MUN)	E(6)(7)	E		E
Agricultural Supply: Irrigation (AGR)	E	E	E	E
Agricultural Supply: Stock Watering (AGR)	E	E	E	E
Industrial Process Supply (PRO)	E			E
Industrial Service Supply (IND)	E			E
Water Contact Recreation (REC 1)	E	E	E	E
Non-contact Water Recreation (REC-2)	E	E	E	E
Warm Freshwater Habitat (WARM)	E	E	E	E
Cold Freshwater Habitat (COLD)	E(6) or P	P	P	E
Migration of Aquatic Organisms: Warm Water (MIGR)	E(6) or n/a		E	E
Migration of Aquatic Organisms: Cold Water (MIGR)	E(6) or n/a		E	E
Fish Spawning, Warm Water (SPWN)	E(6)	E	E	E
Fish Spawning, Cold Water (SPWN)	E(6) or n/a			E
Wildlife Habitat (WILD)	E	E	E	E
Commercial and Sport Fishing (COMM)	E or n/a		E	E

Legend/Notes:

E = Existing Basin Plan Designated Beneficial Use, P = Potential Beneficial Use;

Source: Water Quality Control Plan for the Sacramento River and San Joaquin River Basin, Fifth Edition, Revised May 2018 (CVRWQCB, 2018).

1. The following water bodies in the Cache Slough Drainage are identified as Delta Waterways (Basin Plan Appendix 42) having all or a portion of their extent residing within the legal Delta boundary: Alamo Creek (Old Alamo Creek, New Alamo Creek), Barker Slough, Cache Slough, Elkhorn Slough, Haas Slough, Lindsey Slough, Miner Slough, Prospect Slough, Steamboat Slough, Sweany Creek, and Ulatis Creek) and there beneficial uses are those designated for the Sacramento-San Joaquin Delta.

2. For all or a portion of the extent of the following water bodies that reside outside of the legal Delta boundary, it is assumed that their beneficial uses are the same as those designated for Putah Creek: Lake Berryessa to Yolo Bypass segment: Alamo Creek (Old Alamo Creek, New Alamos Creek), Barker Slough, Encinosa Creek, English Creek, Gibson Canyon Creek, Laguna Creek, Putah South Canal, Sweany Creek, and Ulatis Creek.

3. Beneficial uses for the Putah Creek South Drainage are described in the Basin Plan by the Putah Creek: Lake Berryessa to Yolo Bypass segment.

4. Beneficial uses for the Southwest Yolo Bypass Drainage are described in the Basin Plan by the Yolo Bypass segment.

5. Beneficial uses for the Sacramento River drainage in the Solano Subwatershed are described in the Basin Plan as those beneficial uses designated for the Sacramento-San Joaquin Delta.

6. MUN, COLD, MIGR, and SPWN do not apply to Old Alamo Creek (Basin Plan II-2.00).

7. New Alamo Creek and Ulatis Creek are designated with the MUN beneficial use (Basin Plan IV-37.05).

2.2 CONSTITUENT OF CONCERN SOURCES, FATE, AND TRANSPORT

PUR data from CDPR for the Cache Slough drainage show agricultural applications of pyrethroids as having a bimodal distribution with peaks in March and July-August (see **Figure B1**). Non-agricultural applications across Solano County also show two peaks in application: May and October (see **Figure B2**). With regard to the specific month, April, in which both Coalition sediment toxicity exceedances were observed during 2018 and 2019, and the month prior to those exceedances, March, PUR data show the greatest amount of pyrethroids (on a pounds of active ingredient (A.I.) basis) applied on alfalfa, apple, pear, and tomato (see **Table A1** and **Table A3**). Non-agricultural applications of pyrethroids in March and April are dominated by structural pest control applications (see **Table A2** and **Table A4**).

In taking a closer look at pyrethroid applications made by irrigated agriculture in the entire Cache Slough drainage (which includes parcels that drain into the system both upstream and downstream of the monitoring site) during March and April as a means to identify those active ingredients and associated commodities with the greatest potential to result in the discharge of pyrethroids to receiving waters and impact water quality, it is necessary to identify the pyrethroids measured in the sediment samples showing toxicity to *Hyalella* (see **Table A5**) and their relative rates of application (pounds of A.I. applied) leading up to the observed sediment toxicity exceedances (see **Table A1** and **Table A3**).

Such an evaluation identified bifenthrin and lambda-cyhalothrin as the two pyrethroids detected in sediment samples collected in Ulatis Creek that could have contributed to the observed toxicity (April 17, 2018 sample) and were sufficient to cause the observed toxicity to *Hyalella* (April 18, 2019, sample). The applications of these two pyrethroids were made in the greatest amounts to alfalfa, barley, and tomato prior to the April 2018 sediment toxicity exceedance (see highlighted rows in **Table A1**) and to alfalfa, tomato, and pear prior to the April 2019 exceedance (see highlighted rows in **Table A3**). The pear orchards where bifenthrin and lambda-cyhalothrin were applied during the time period under consideration are located downstream of the UCBRD monitoring site, but because of the representative nature of the monitoring site with respect to agricultural applications of the two pyrethroids throughout Solano County it is necessary to inform pear growers of the potential risks to surface water quality when applying pyrethroids. The amount of A.I. applied and the percent of total A.I. applied during the two-month period prior to the observed sediment toxicity exceedances were also considered in order to identify those pyrethroid-commodity combinations with the greatest potential to impact receiving water quality if pyrethroid applications result in discharges to local water bodies. Additionally, bifenthrin and lambda-cyhalothrin also are the two pyrethroids applied in the greatest amounts by irrigated agriculture for insect control in Solano County when analyzing PUR data collected for 2016 through 2018, as shown in **Figure B3**.

The pyrethroids, as a class of pesticide, are highly non-polar and feature low water solubility, low volatility, high octanol-water partition coefficients, and have high affinity for soil and sediment particulate matter. Pyrethroids have low mobility in soil and are sorbed strongly to the sediments of natural water systems. Due to these characteristics, pyrethroids are not readily transported in dissolved form, but have a high tendency to attach to fine soil particles and be transported in irrigation tailwater, storm runoff, and/or through application drift or overspray. They show varying persistence in the environment depending on their exposure to air and sunlight. Generally, pyrethroid half-life in soils ranges from 1 to 2 months, and in aquatic sediments from months to years. They have a moderate to high potential to persist in the environment.

A review of daily precipitation data recorded in Solano County approximately 5 miles southeast of the Ulatis Creek monitoring site revealed that the only monitoring event likely influenced by rainfall runoff in the Cache Slough drainage was the April 2018 event (Event 146). Just under 0.30 inches of rainfall occurred on the day before the April 17, 2018, monitoring event. However, based on the timing and intensity of the rainfall and travel time of any upstream discharges, it is uncertain whether upstream urban discharges could have contributed to measurable pollutant concentrations measured at the UCBRD site. There was approximately 0.1 inches of antecedent precipitation recorded three days before the April 18, 2019, sediment toxicity exceedance and an additional 0.2 inches of rain recorded during the preceding 18 days. It is unlikely that much, if any, storm runoff entered Ulatis Creek in the three weeks leading up to the April 2019 (Event 158) sediment toxicity exceedance (see **Table A6**).

It is important to note that due to the persistence of pyrethroids in aquatic sediments, the individual insecticides that may be measured in sediment samples showing toxicity to *Hyalella* could have been deposited months or even years prior to the sample collection that showed toxicity. The extended persistence of pyrethroids in aquatic sediments and the extensive use of pyrethroids by irrigated agriculture, licensed non-agricultural professional applicators, and non-licensed user groups in urban areas (see **Table 2**) make it extremely difficult to trace observed toxicity to a particular source or individual application.

Based on potential transport pathways, effective best management practices (BMPs) that *could* be employed, and in many cases are already employed, by growers and applicators to minimize the risks of pyrethroid contamination in surface waters and sediments include:

- Using alternative pest control materials (i.e., using non-pyrethroid pesticides)
- Reducing the quantity of pesticides applied by monitoring pest and beneficial populations to determine the need for pesticides and the best timing for maximum control
- Reducing the quantity of pesticides applied with spray buffers at field edges and near ditches
- Reducing drift by regular calibration of sprayers for pesticide applications
- Reducing drift by using electrostatic sprayer equipment
- Reducing drift by using effective drift control mechanisms
- Maximizing time between application and planned irrigation runoff and/or predicted storm runoff events in order to reduce loss of applied pesticides from foliage, transport on soils, and transport of pesticides bound to particles in tailwater
- Changing to more efficient application methods (e.g., ground vs. aerial applications and/or equipment that provides more precise applications)
- Installation of vegetated filters between application areas and ditches and/or allowing vegetation to grow in drainage ditches to reduce movement of pesticides bound to soil particles and contamination from aerial overspray (Note: vegetated BMPs may be less effective for very fine-textured clay soils)
- Reducing irrigation tailwater through conversion from flood or furrow irrigation to buried drip, sprinkler, or micro-irrigation where applicable
- Reducing irrigation tailwater with tailwater return systems
- Reducing or delaying irrigation tailwater through irrigation water management
- Sediment and erosion control practices

A diagram showing the general pathways for transport of agriculturally applied pyrethroids to surface waters and practices to minimize the risk of off-site pyrethroid transport is provided in **Appendix C**.

2.3 BASELINE PRACTICES INVENTORY

The Coalition's 2017 Farm Evaluation Survey data show that growers and applicators in the Cache Slough drainage and represented drainages are currently implementing a suite of practices in the following three categories that contribute to preventing pesticides from entering surface waters: pesticide application practices, irrigation practices for managing sediment and erosion, and cultural practices to manage sediment and erosion. A baseline summary of practices by (1) practice category and (2) number of acres represented by an individual practice is provide in **Table 5**. The term *baseline* is used because it represents the starting point considered for comparisons to future rates of management practice implementation.

Table 5: Baseline Summary of Practices Implemented in the Cache Slough and Represented Drainages to Prevent Pesticides from Entering Surface Waters.

PRACTICE CATEGORY / **Individual Practice**	**Acres Reported**	**Percent of Total Acres (121,236 acres)**
PESTICIDE APPPLICATION PRACTICES		
Follow Label Restrictions	115,740	91.1%
Avoid Surface Water When Spraying	114,432	90.0%
Monitor Wind Conditions	113,893	89.6%
County Permit Followed	111,745	87.9%
Use PCA Recommendations	110,266	86.8%
Monitor Rain Forecasts	109,741	86.4%
Attend Trainings	108,552	85.4%
End of Row Shutoff When Spraying	105,711	83.2%
Use Appropriate Buffer Zones	104,554	82.3%
Use Drift Control Agents	104,462	82.2%
Sensitive Areas Mapped	79,835	62.8%
Reapply Rinsate to Treated Field	66,759	52.5%
Use Vegetated Drain Ditches	49,901	39.3%
Target Sensing Sprayer used	21,794	17.1%
No Pesticides Applied	11,795	9.3%
Chemigation	11,093	8.7%
Other1	6,455	5.1%
Other	26	0.02%
No Selection	20	0.02%
IRRIGATION PRACTICES FOR MANAGING SEDIMENT AND EROSION		
The time between pesticide applications and the next irrigation is lengthened as much as possible to mitigate runoff of pesticide residue.	87,595	68.9%
Shorter irrigation runs are used with checks to manage and capture flows.	59,622	46.9%
Use drip or micro-irrigation to eliminate irrigation drainage.	39,759	31.3%
In-furrow dams are used to increase infiltration and settling out of sediment prior to entering the tail ditch.	35,793	28.2%

PRACTICE CATEGORY **Individual Practice**	**Acres Reported**	**Percent of Total Acres (121,236 acres)**
IRR PRACTICES FOR MANAGING SEDIMENT AND EROSION – continued		
Tailwater Return System.	35,363	27.8%
Use of flow dissipaters to minimize erosion at discharge point.	23,263	18.3%
No irrigation drainage due to field or soil conditions.	21,641	17.0%
Catchment Basin.	21,090	16.6%
Other	19,267	15.2%
No Selection	1,238	1.0%
PAM (polyacrylamide) used in furrow and flood irrigated fields to help bind sediment and increase infiltration.	589	0.5%
CULTURAL PRACTICES TO MANAGE SEDIMENT AND EROSION		
Soil water penetration has been increased through the use of amendments, deep ripping and/or aeration.	90,551	71.3%
Crop rows are graded, directed and at a length that will optimize the use of rain and irrigation water.	76,911	60.5%
Minimum tillage incorporated to minimize erosion.	65,112	51.2%
Vegetated ditches are used to remove sediment as well as water soluble pesticides, phosphate fertilizers and some forms of nitrogen.	50,054	39.4%
Cover crops or native vegetation are used to reduce erosion.	48,480	38.1%
Storm water is captured using field borders.	46,632	36.7%
Berms are constructed at low ends of fields to capture runoff and trap sediment.	27,397	21.6%
Sediment basins / holding ponds are used to settle out sediment and hydrophobic pesticides such as pyrethroids from irrigation and storm runoff.	22,480	17.7%
Vegetative filter strips and buffers are used to capture flows.	21,859	17.2%
Subsurface pipelines are used to channel runoff water.	20,204	15.9%
Hedgerows or trees are used to help stabilize soils and trap sediment movement.	20,198	15.9%
Creek banks and stream banks have been stabilized.	19,817	15.6%

PRACTICE CATEGORY / **Individual Practice**	**Acres Reported**	**Percent of Total Acres (121,236 acres)**
CULTURAL PRACTICES TO MANAGE SEDIMENT AND EROSION – continued		
No storm drainage due to field or soil conditions.	10,072	7.9%
Other	7,161	5.6%
Field is lower than surrounding terrain.	5,681	4.5%
No Selection	1,187	0.9%

2.4 CONSTITUENT OF CONCERN: WATER QUALITY DATA

The Coalition has observed three exceedances of the ILRP trigger limit for *Hyalella* sediment toxicity in the Cache Slough drainage since it began sampling in March 2006. The total number of sample events with toxicity exceedances for *Hyalella* in the drainage is three out of 13 sample events. The three *Hyalella* toxicity trigger limit exceedances observed in the Cache Slough drainage from March 2006 through April 2019 are shown in **Table 6**. The first exceedance shown in **Table 6** (Event 66) was not attributed to any pyrethroid as the only pyrethroid detected in the sediment sample was lambda-cyhalothrin with a total organic carbon-normalized concentration of less than 0.1 Toxic Units (TUs). Chlorpyrifos was not detected in that sample.

Table 6: Acute Sediment Toxicity Exceedances for *Hyalella azteca* Observed in the Cache Slough Drainage: March 2006 – April 2019.

Site	Date	Event	Analyte (% of Control)	Result
UCBRD	08/16/2011	66	*Hyalella* - survival	54.4
	04/17/2018	146		67.7
	04/18/2019	158		77.2

This Management Plan is written to address *Hyalella* sediment toxicity in Ulatis Creek suspected of being contributed to (Event 146) and caused by (Event 158) pyrethroids (specifically, bifenthrin and lambda-cyhalothrin), as evidenced by exceedances of the ILRP toxicity trigger limit for *Hyalella* sediment toxicity and detected sediment concentrations of bifenthrin and lambda-cyhalothrin observed for these two events (see **Table A5**).

3 Management Plan Strategy

The three observed *Hyalella* sediment toxicity exceedances are indicative of one or more pollutants being present in the Cache Slough drainage that have potential for affecting aquatic life. The pollutants suspected of contributing to the April 17, 2018 and causing April 18, 2019 the observed toxicity are bifenthrin and lambda-cyhalothrin. The toxicities may or may not be associated with the agricultural use of these two insecticides, since non-agricultural uses of these pyrethroids are documented in CDPR PUR records during the two months prior to the exceedances. However, due to the use of pyrethroids by irrigated agriculture during the time period leading up to the observed sediment toxicity exceedances, Dixon/Solano RCD Water Quality Coalition (Dixon/Solano Coalition) Members in the Cache Slough represented drainages are required to implement a management strategy to reduce the risk of sediment toxicity to *Hyalella* and thus, help to improve surface water quality in these drainages.

3.1 MANAGEMENT PLAN APPROACH

Dixon/Solano Coalition efforts from 2005 to 2016 to address earlier *Hyalella* sediment toxicity observed in Z-Drain were effective in reducing the discharge of pyrethroids from agricultural fields, significantly lowering the sediment concentrations of these insecticides, preventing sediment toxicity to *Hyalella*, and allowing the preparation of a Request to Complete the Management Plan for *Hyalella* Sediment Toxicity in Z-Drain that was approved by the Central Valley Water Board on August 3, 2017. Initially, the same outreach and education approach at all levels (growers, applicators, pest control advisors (PCAs)) will be employed to ensure that users of pyrethroids are aware of the sediment toxicity exceedances that occurred in April 2018 and April 2019, as well as recommended practices to minimize the discharge of pyrethroids to surface waters. Growers will continue to implement practices focused on the management of irrigation tailwater to limit sediment and erosion, the implementation of cultural practices to control sediment and erosion, the use of alternative pest control materials, and additional pesticide application practices.

For the first 18 months of this Management Plan, Dixon/Solano RCD Water Quality Coalition staff (Coalition staff) will focus on targeted outreach, education and gathering feedback on specific practices from growers during the first 18 months of Management Plan implementation. Growers will maintain their current high levels of management practice implementation to control or reduce the risk of discharges of pyrethroids to surface waters. The Dixon/Solano RCD Water Quality Coalition's current recommended management practices for the control of pyrethroids are shown in **Appendix D**.

During the first 18 months of Management Plan implementation and leading up to the Coalition's next Farm Evaluation conducted for the 2020 crop year, the Dixon RCD proposes to utilize the Coalition's online data management system to specifically track (1) pesticide application practices, (2) irrigation practices for managing sediment and erosion, and (3) cultural practices to manage sediment and erosion employed by those growers who apply pyrethroids in the Cache Slough drainage and represented drainages. This targeted survey information will be reviewed and integrated as appropriate to update the Dixon/Solano RCD Water Quality Coalition's *Pyrethroid Facts and Recommended Practices* (**Appendix D**). The suite of updated management practices for the control of discharge of pyrethroids to surface waters will then be used by the Dixon/Solano Coalition and implemented by growers and applicators.

The Subwatershed's current and future approach to managing any toxicity exceedance in the Cache Slough drainage and represented drainages includes a robust education campaign. The impetus of this effort is to maintain the high degree of awareness of past *Hyalella* sediment toxicity exceedances at the Z-Drain monitoring site and the implementation of management practices currently employed in the Cache Slough drainage and represented drainages related to pyrethroid application practices and cultural practices to manage sediment and erosion. These are practices that are known to control or reduce the risk of discharges of pyrethroids to surface waters. Based on the results of the 2017 Farm Evaluation Survey, as summarized in the Practices Inventory provided in **Table 5**, nearly all growers in the four drainages are already implementing the agricultural practices necessary to prevent the discharge of pesticides to surface waters. The Dixon/Solano Coalition will continue to encourage Coalition Members in the Cache Slough represented drainages to continue implementation of the practices summarized in **Table 5** under this Management Plan.

3.2 ACTIONS AND TASKS

3.2.1 Summary of Actions Taken to Date

Since the Dixon/Solano Coalition was made aware of the two most recent *Hyalella* sediment toxicity exceedances, it has initiated the following actions:

- Email ALERT sent to 322 pesticide applicators/pest control advisors on May 24, 2018. The ALERT included notification of sediment toxicity observed April 17th, 2018, the historical connection between pyrethroid detections and sediment toxicity, as well as a list of trade names with pyrethroids as active ingredients.
- Presentations at 3 Solano County Agricultural Commissioner Applicator Trainings (November, December 2018 and January 2019) with 104 participants total.

3.2.2 Performance Goals

Beginning in December 2010 and continuing currently, Coalition Members in the Cache Slough represented drainages have received targeted outreach and education associated with pyrethroid application and runoff management practices that minimize the potential for these insecticides to impact surface waters that is informed by the Pyrethroid Action Plan developed for Z-Drain. Monitoring results from 2013 through 2019 for Ulatis Creek at Brown Road reflect the increased attention and implementation of management practices that have reduced the levels of pesticides and toxicity exceedances in the receiving water. The effectiveness of these actions implemented by growers and applicators in the Cache Slough drainage and represented drainages will continue to be evaluated through review of Assessment and/or Management Plan monitoring data, and the evaluation of Farm Evaluation survey results. The Dixon/Solano Subwatershed and Coalition Members in the Cache Slough represented drainages seek to meet the three performance goals shown in **Table 7** as they relate to the application of pyrethroids.

Table 7: Management Practice Performance Goals for Pyrethroid Applications in the Cache Slough Drainage and Represented Drainages.

Performance Goal	Mechanism of Achieving Goal	Quantitative Measure of Progress	Schedule for Achieving Goal
1. Maintain education and awareness of pyrethroid application and runoff management practices that minimize the potential for impacts to surface waters. Use targeted grower survey information, beginning with 2020 Crop Year and consultation with growers, PCAs, applicators and technical advisors to refine, as necessary, existing management practices for the control of pyrethroid discharges.	Dixon/Solano Coalition to provide *Hyalella* Toxicity Management Plan Updates annually through presentations at three Solano County Ag Commissioner pesticide applicator trainings, written updates in annual newsletter, and/or direct season of use mailings (through email and US mail) to all Coalition members who apply or may apply pyrethroids, as well as PCAs and commercial applicators operating locally. The updates will include information to educate applicators in the Cache Slough and represented drainages on management practices that minimize the potential for pyrethroids to be discharged to surface waters. Mailings and/or phone calls to growers regarding appropriate BMPs will also be counted as successful completion of these goals.	Achievement of this performance goal will be measured based on attendance and/or receipt of outreach materials. Outreach activities to be documented in Annual Monitoring Report and tabulated in annual Management Plan Progress Report. *Reporting Basis:* *Meeting dates, numbers of attendees at meetings, and recipients of mailings and/or phone calls covering these management practice topics.*	Ongoing: 100% achievement of this performance goal will occur in every year from the date the Management Plan is submitted for approval to the Executive Officer.

Performance Goal	Mechanism of Achieving Goal	Quantitative Measure of Progress	Schedule for Achieving Goal
2. Maintain implementation of pyrethroid application and runoff management practices that minimize the potential for impacts to surface waters in the Cache Slough and represented drainages. Use targeted grower survey information beginning with 2020 Crop Year and consultation with growers, PCAs, applicators and technical advisors to refine, as necessary, existing management practices for the control of pyrethroid discharges.	Maintain awareness of and employ ideas of growers, PCAs, and applicators in the Cache Slough drainage and represented drainages through annual outreach activities, targeted outreach reminders about management practices that are effective in reducing or preventing discharge of pyrethroids to surface waters.	Achievement of this performance goal will be measured by comparing and reporting management practices implemented and reported in the 2017 Farm Evaluations (see **Table** 5) to those reported by growers in the Cache Slough Drainage for the 2020 crop year and additional crop years, as necessary, during the compliance timeframe for this Management Plan. *Reporting Basis:* *Acreages of implemented management practices in the Cache Slough and represented drainages and annual reporting of outreach statistics.*	Achievement of this performance goal will occur annually through the proposed 3-year compliance timeframe for this Management Plan.
3. Avoid exceedance (caused by agricultural activities) of ILRP toxicity trigger limit in Ulatis Creek at Brown Road sediment samples.	Educate applicators in the Cache Slough and represented drainages through outreach activities on how to reduce or prevent discharge of pyrethroids to surface waters.	Achievement of this performance goal will be measured through evaluation of the Coalition's *Hyalella* toxicity data collected in Ulatis Creek at Brown Road. *Reporting Basis:* *All annual monitoring results, including exceedance reports, if applicable.*	Maintain 100% compliance with the ILRP trigger limit through the proposed 3-year compliance timeframe for this Management Plan (August 2019 through August 2022).

3.2.3 Member Education

Member education takes the forms of general outreach to all members of the Dixon/Solano Subwatershed and more targeted outreach to growers, pest control advisers (PCAs), and pesticide applicators (including potential users of pyrethroid products), as necessary. General outreach at the subwatershed level is directed to landowners, farm operators, pesticide applicators and PCAs. Outreach is focused on the potential cause(s) of sediment toxicity to *Hyalella* and the continued implementation of best management practices (BMPs) that prevent the movement of pyrethroids into Sacramento Valley surface waters. These general outreach efforts are carried out through presentations at grower meetings and via direct outreach (mailings, phone calls, emails). Targeted outreach will be directed to landowners, growers, pesticide applicators and PCAs operating in high priority lands near Ulatis Creek and throughout the Cache Slough represented drainages.

The effectiveness of future Management Plan outreach efforts will be assessed by tracking the number of attendees at meetings, tracking management practice implementation related to irrigation systems and management, cultural practices to manage sediment and erosion, pesticide application practices, and compliance with WQOs for Assessment and/or Management Plan monitoring events.

3.2.4 Management Practices

Coalition Members in the Cache Slough represented drainages are expected to continue to employ at high levels the agricultural management practices known to minimize the movement of pesticides into surface waters (see **Table 5**). The performance goals for continued education and awareness of select existing and potential new management practices and their implementation, specific to the use of pyrethroids, are provided in **Table 7**. The effectiveness of these actions implemented by growers and applicators in the Cache Slough drainage and represented drainages will be evaluated through review of Assessment and/or Management Plan monitoring data, evaluation of future Farm Evaluation and other targeted survey results, and Subwatershed pesticide application education activities. In the event that a future exceedance of the ILRP toxicity trigger limit is observed, and pyrethroids are determined to be a potential cause, Coalition staff will use CDPR PUR data to identify possible sources of the observed exceedance and initiate follow-up actions, as necessary.

3.2.5 Management Plan Implementation Schedule

The Coalition's Order requires that the implementation of Management Plans and management practices result in the compliance of a constituent of concern with its applicable WQOs or trigger limits as soon as is reasonably practicable, but no longer than 10 years from submittal of the Management Plan to the Regional Water Board for approval. The Coalition Members in the Cache Slough drainage anticipate that implementation of this Management Plan and its proposed management practices will result in compliance with the ILRP toxicity trigger limit for *Hyalella* within three years of submittal of this Management Plan for approval by the Regional Water Board. The following schedule of actions is proposed for completing this Management Plan:

- August 2019: Development and submittal of Management Plan to Regional Water Board for approval.
- August 2019 – August 2022: Provide Management Plan-specific outreach and education to growers, PCAs, and applicators; Continued implementation of existing management practices and any new practices identified from targeted grower surveys; Continued Assessment and/or Management Plan monitoring; Annual reporting of management practice implementation. The 3-year compliance timeframe represented here is based on the Dixon/Solano Coalition beginning its outreach and education for this Management Plan in August 2019.
- August 2022: If no additional exceedances are observed for *Hyalella* sediment toxicity during 3 years of Assessment and/or Management Plan monitoring, then document water quality and management practices implementation and effectiveness, followed by submittal of a request to Central Valley Water Board Executive Officer for approval of completion of the Management Plan.

3.3 DUTIES AND RESPONSIBILITIES

Implementation of the various elements of the Management Plan will be carried out by the Coalition and their contractors, Dixon/Solano RCD Coalition staff, and Coalition Members according to the organizational chart shown in Error! Reference source not found.. The roles and responsibilities of the individuals and groups specified in the organizational chart who will continue to implement the various elements of this Management Plan are described below.

Sample Collection Lead – Stevi Vasquez, Pacific EcoRisk: Ms. Vasquez will be responsible for directing the field sample collection efforts for this Management Plan.

Water Quality Data Lead – Katrina Arredondo, Larry Walker Associates: Ms. Arredondo will have primary responsibility for processing and managing water quality data.

Quality Assurance Lead – Mike Trouchon, Larry Walker Associates: Mr. Trouchon will oversee water quality data management and has primary responsibility for quality assurance of water quality data.

Management Practice Data Lead – Martha McKeen, Dixon RCD: Ms. McKeen will provide primary oversight for collection, processing, and reporting of Farm Evaluation survey results and other management practice data.

Reporting Lead – Steve Maricle, Larry Walker Associates: Mr. Maricle will oversee preparation of the required annual Management Plan Progress Reports (MPPR).

Project Lead – Kelly Huff, Dixon RCD: Ms. Huff will provide general oversight, review, and schedule tracking for Management Plan implementation, including coordination of needed assistance from the Solano County Agricultural Commissioner. In the event of a future exceedance of the ILRP toxicity trigger limit, Ms. Huff will review PUR data to identify a possible source of the observed exceedance and initiate follow-up actions, as necessary.

Education and Outreach Lead – Kelly Huff, Dixon RCD: Ms. Huff will be responsible for development of outreach materials and tracking and documenting member outreach and education for the Management Plan.

Coalition Members in Represented Drainages: Coalition Members in the Cache Slough represented drainages are responsible for continued implementation of the agricultural management practices needed to comply with WQOs. Coalition Members are also responsible for providing information requested and collected by the Coalition pursuant to the implementation of this Management Plan and management practices.

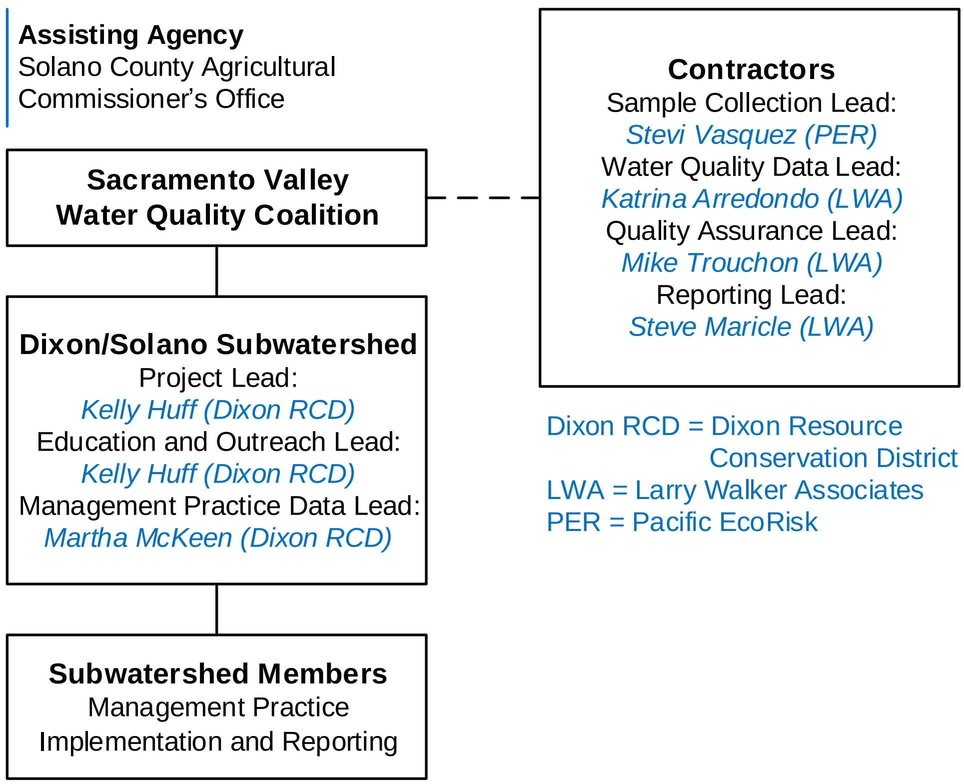

Figure 3: Ulatis Creek Management Plan for Hyalella Sediment Toxicity – Project Organization.

4 Monitoring Design

Surface water quality monitoring performed in support of this Management Plan (i.e., Management Plan monitoring) is designed to measure effectiveness at achieving the goals and objectives of the Comprehensive Surface Water Quality Management Plan (CSQMP). This will be achieved by conducting Management Plan monitoring in the representative Cache Slough drainage at the Ulatis Creek at Brown Road (UCBRD) monitoring location (see **Figure 1**) that is used by the Coalition for its Assessment monitoring. The Coalition will use both Assessment monitoring and Management Plan monitoring at UCBRD to show compliance with the ILRP trigger limit for *Hyalella* sediment toxicity. The Coalition submitted its Annual Monitoring Plan Update for the 2020 monitoring year (October 2019 – September 2020) on August 1, 2019 and has not been conditionally approved by the Central Valley Water Board as of the submittal date of this Management Plan. The proposed monitoring for this Management Plan (until it is approved for completion) is part of the Annual Monitoring Plan Update submitted annually on August 1 to the Regional Water Board for approval.

4.1 MONITORING

Management Plan monitoring in the Cache Slough drainage included in the Annual Monitoring Plan Update for the 2020 monitoring year is focused on one monitoring event scheduled for April 2020. The Management Plan monitoring for *Hyalella* sediment toxicity is focused on the month of April because that is the month during which the two most recent ILRP trigger limit exceedances occurred (see **Table 6**). Sample collection and analysis for *Hyalella* sediment toxicity testing during Management Plan monitoring will be identical to that employed by the Coalition during Assessment monitoring. Monitoring results will be submitted electronically to the Regional Water Board with the quarterly data submittals required by the WDR.

5 Data Evaluation

The effectiveness of this Management Plan will be evaluated through (1) review of progress made toward implementation of education and outreach activities proposed to maintain awareness of water quality issues as they pertain to pyrethroid application, (2) assessment of agricultural management practices known to limit the transport of agriculturally-applied pyrethroids to surface waters, and (3) collection of sediment toxicity data to determine the effectiveness of management practices implementation in reducing the exceedances of the ILRP sediment toxicity trigger limit in the Ulatis Creek drainage. Farm Evaluation survey data (e.g., implementation rates of pesticide application practices, irrigation practices for managing sediment and erosion, and cultural practices to manage sediment and erosion) collected in the Cache Slough drainage and represented drainages will be used in conjunction with targeted survey results to track progress in implementing specific agricultural practices identified to reduce or eliminate the discharge of pyrethroids in spray drift, irrigation tailwater, and storm runoff to ambient surface waters.

5.1 EVALUATION OF MANAGEMENT PLAN EFFECTIVENESS

The effectiveness of this Management Plan primarily will be judged on maintaining improvements in surface water quality since August 2019 as measured in the representative Cache Slough drainage. Continued lack of exceedances of the ILRP toxicity trigger limit, along with documentation of the implementation of management practices described in the Actions and Task subsection, will be used to link observed surface water quality improvements to the actions of growers in the drainage. Additionally, Management Plan effectiveness will also be assessed with regard to the progress made toward implementation of existing and potential future management actions identified to improve surface water quality in the Cache Slough drainage. Status and effectiveness of this Management Plan will be described annually in the MPPR through presentation of the following information:

- Time series plot of *Hyalella* toxicity testing data collected at the Ulatis Creek at Brown Road (UCBRD) monitoring location;
- Tabular summary of meeting annual Dixon/Solano Coalition outreach and education goals; and
- Tabular summary of management practices implemented under this Management Plan for comparison to baseline 2017 management practices implemented prior to initiation of Management Plan activities.

6 Records and Reporting

The Coalition submits a Management Plan Progress Report (MPPR) annually on May 1 that summarizes the progress made to date on each Management Plan. The MPPR will contain the reporting components required for this Management Plan, as well as all other Management Plans. The Coalition also submits a Monitoring Plan Update report (annually on August 1) with the monitoring schedules and constituents for the upcoming monitoring year, including those required by Management Plans. These reports and schedules are consistent with the requirements in Appendix MRP-1 of the Coalition's WDR.

6.1 DOCUMENTATION AND REPORTING

The water quality monitoring data collected pursuant to this Management Plan (i.e., Assessment and Management Plan monitoring data) will be submitted electronically to the Central Valley Water Board on a quarterly basis along with all other monitoring data collected by the Coalition. An event-based water quality exceedances report is also provided to the Central Valley Water Board on a more or less monthly schedule. Management Plan monitoring data will be evaluated by the Water Quality Data Lead and Quality Assurance Lead (Katrina Arredondo and Mike Trouchon, respectively, of LWA) to ensure that data conform to the Coalition's Quality Assurance Project Plan (QAPP) and meet the requirements of the WDR. The exceedance reports and quarterly submittal of Management Plan monitoring data will provide adequate and timely information regarding compliance of ambient water quality with the ILRP toxicity trigger limit. The Subwatershed Project Lead (Kelly Huff) will provide data on management practices implementation and performance goals as set forth in this Management Plan and the Education and Outreach Lead (Kelly Huff) will report on education and outreach efforts for inclusion in the MPPR. All required information will be summarized annually in the MPPR, along with the most recent and previous year's Management Plan monitoring data.

7 References

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Appendix A: Pyrethroid Pesticide and Precipitation Data Associated with Observed *Hyalella* Toxicity Exceedances

Table A1: Pyrethroids Applied by Irrigated Agriculture in the Cache Slough Drainages Two Months Prior to Observed April 2018 Sediment Toxicity Exceedance.

Commodity	Active Ingredient (A.I.)	lb Applied per Period	>1 lb A.I. Applied	>1% of Total lb A.I. Applied	Detected in Sediment	Sig. Contrib. to Additive Toxicity
Alfalfa	Lambda-Cyhalothrin	323.25	**Yes**	**Yes**	**Yes**	**Yes**
Alfalfa	Cypermethrin	52.43	**Yes**	**Yes**	**Yes**	no
Apple	Fenpropathrin	42.37	**Yes**	**Yes**	no	no
Barley, Malting	Lambda-Cyhalothrin	7.19	**Yes**	**Yes**	**Yes**	**Yes**
Barley, For/Fod		3.77	**Yes**	**Yes**	**Yes**	**Yes**
Cabbage	Lambda-Cyhalothrin	0.13	no	no	**Yes**	**Yes**
	Cyfluthrin	0.04	no	**Yes**	**Yes**	no
Nursery-Outdoor Plants	Fenpropathrin	1.82	**Yes**	**Yes**	no	no
	Cyfluthrin	0.23	no	**Yes**	**Yes**	no
Onion Seed	Lambda-Cyhalothrin	1.12	**Yes**	no	**Yes**	**Yes**
Pear	Fenpropathrin	103.73	**Yes**	**Yes**	no	no
	Lambda-Cyhalothrin	1.46	**Yes**	no	**Yes**	**Yes**
Prune	Cyfluthrin	0.75	no	**Yes**	**Yes**	no
Tomato	Lambda-Cyhalothrin	13.29	**Yes**	**Yes**	**Yes**	**Yes**
	Bifenthrin	8.2	**Yes**	**Yes**	**Yes**	**Yes**
Tomato, Process	Lambda-Cyhalothrin	0.67	no	no	**Yes**	**Yes**
Walnut	Lambda-Cyhalothrin	3.21	**Yes**	no	**Yes**	**Yes**

Highlighted commodities and active ingredients are those targeted for specific outreach and education activities due to their amount of use, detection in sediments shown to be toxic to *Hyalella*, and relative toxicity to sensitive invertebrates.

Table A2: Pyrethroids Applied by Licensed Pest Control Applicators (Non-Agriculture) in Solano County Two Months Prior to Observed April 2018 Sediment Toxicity Exceedance.

Use	Active Ingredient (A.I.)	lb Applied per Period	Detected in Sediment	Sig. Contrib. to Additive Toxicity
Landscape Maintenance	Permethrin	0.27	**Yes**	no
Landscape Maintenance	Lambda-Cyhalothrin	0.14	**Yes**	**Yes**
	Bifenthrin	0.03	**Yes**	**Yes**
Regulatory Pest Control	Esfenvalerate	0.02	**Yes**	no
Structural Pest Control	Bifenthrin	145.45	**Yes**	**Yes**
Structural Pest Control	Permethrin	32.42	**Yes**	no
	Deltamethrin	18.79	no	no
	Cypermethrin	17.64	**Yes**	no
	Cyfluthrin	16.42	**Yes**	no
Structural Pest Control	Lambda-Cyhalothrin	1.5	**Yes**	**Yes**
Structural Pest Control	Esfenvalerate	0.13	**Yes**	no

Highlighted uses and active ingredients are those with greatest potential to have contributed to observed sediment toxicity to *Hyalella* due to detection in sediments shown to be toxic to *Hyalella*, and relative toxicity to sensitive invertebrates.

Table A3: Pyrethroids Applied by Irrigated Agriculture in the Cache Slough Drainages Two Months Prior to Observed April 2019 Sediment Toxicity Exceedance.

Commodity	Active Ingredient (A.I.)	lb Applied per Period	>1 lb A.I. Applied	>1% of Total lb A.I. Applied	Detected in Sediment	Sig. Contrib. to Additive Toxicity
Alfalfa	Lambda-Cyhalothrin	132.98	**Yes**	**Yes**	**Yes**	**Yes**
Nursery-Outdoor Plants	Bifenthrin	0.43	no	**Yes**	**Yes**	**Yes**
	Fenpropathrin	0.10	no	**Yes**	no	no
Pear	Lambda-Cyhalothrin	1.46	**Yes**	**Yes**	**Yes**	**Yes**
Tomato	Lambda-Cyhalothrin	4.65	**Yes**	**Yes**	**Yes**	**Yes**
Tomato, Process	Bifenthrin	1.80	**Yes**	**Yes**	**Yes**	**Yes**

Highlighted commodities and active ingredients are those targeted for specific outreach and education activities due to their amount of use, detection in sediments shown to be toxic to *Hyalella*, and relative toxicity to sensitive invertebrates.

Table A4: Pyrethroids Applied by Licensed Pest Control Applicators (Non-Agriculture) in Solano County Two Months Prior to Observed April 2019 Sediment Toxicity Exceedance.

Use	Active Ingredient (A.I.)	lb Applied per Period	Detected in Sediment	Sig. Contrib. to Additive Toxicity
Landscape Maintenance	Bifenthrin	0.09	**Yes**	**Yes**
Landscape Maintenance	Deltamethrin	0.05	no	no
	Cyfluthrin	0.02	no	no
Structural Pest Control	Bifenthrin	13.47	**Yes**	**Yes**
Structural Pest Control	Cyfluthrin	9.59	no	no
	Permethrin	4.63	no	no
	Deltamethrin	4.19	no	no
	Cypermethrin	1.91	no	no
Structural Pest Control	Lambda-Cyhalothrin	0.37	**Yes**	**Yes**
Structural Pest Control	Esfenvalerate	0.28	no	no

Highlighted uses and active ingredients are those with greatest potential to have contributed to observed sediment toxicity to *Hyalella* due to detection in sediments shown to be toxic to *Hyalella*, and relative toxicity to sensitive invertebrates.

Table A5: UCBRD *Hyalella* Sediment Toxicity Test Results and Associated Sediment Analyses for Pyrethroids and Chlorpyrifos.

Event	Sample Date	*Hyalella* Survival, % of Control	Est. TUs in *Hyalella* Sediment Test	Est. TUs Attributable to Chlorpyrifos	Est. TUs Attrib. to Individual Detected Pyrethroids	Sediment TOC (mg/kg)
146	04/17/2018	**73.4[(1)]**	0.459	0 chlorpyrifos non-detect	Bifenthrin = 0.273 Cyfluthrin = 0.011 Cypermethrin = 0.020 Esfenvalerate = 0.011 Lambda-Cyhalothrin = 0.143 Permethrin = 0.001	31,000
150	08/21/2018	105.9[(2)]	---	---	---	---
158	04/18/2019	**64.6[(1)]**	**1.164[(3)]**	0 chlorpyrifos non-detect	Bifenthrin = 0.437 Lambda-Cyhalothrin = 0.727	11,000
162	08/21/2019	97.4[(2)]	---	---	---	---

1. Sample showed statistically significant toxicity and < 80% organism survival as compared to controls.
2. Sample did not show toxicity and therefore, follow-up sediment analysis for pyrethroids and chlorpyrifos not required.
3. Estimated (est.) Toxic Units (TUs) based on the sum of normalized sediment pesticide concentrations (mg/kg total organic carbon (TOC)) measured for bifenthrin, chlorpyrifos, cyfluthrin, cypermethrin, deltamethrin, esfenvalerate, fenpropathrin, lambda-cyhalothrin, and permethrin. A TU sum > 1 suggests that pyrethroid sediment concentrations are sufficient to cause toxicity to *Hyalella* (Amweg et al., 2005).

Table A6: Antecedent Precipitation Data for Sediment Toxicity Exceedances Observed in Ulatis Creek.

Antecedent Rainfall Conditions	Event 146 (04/17/2018)	Event 158 (04/18/2019)
Date of last 0.10" Days since 0.10"	04/16/2018 1 day	04/15/2019 3 days
Date of last 0.25" Days since 0.25"	04/16/2018 1 day	03/27/2019 22 days
Date of last 0.75" Days since 0.75"	03/01/2018 47 days	02/26/2019 51 days

Note: Precipitation data from CIMIS site 212 (Hastings Tract East) in Solano County.

Appendix B: Agricultural and Non-Agricultural Pyrethroid Pesticide Use in Solano County

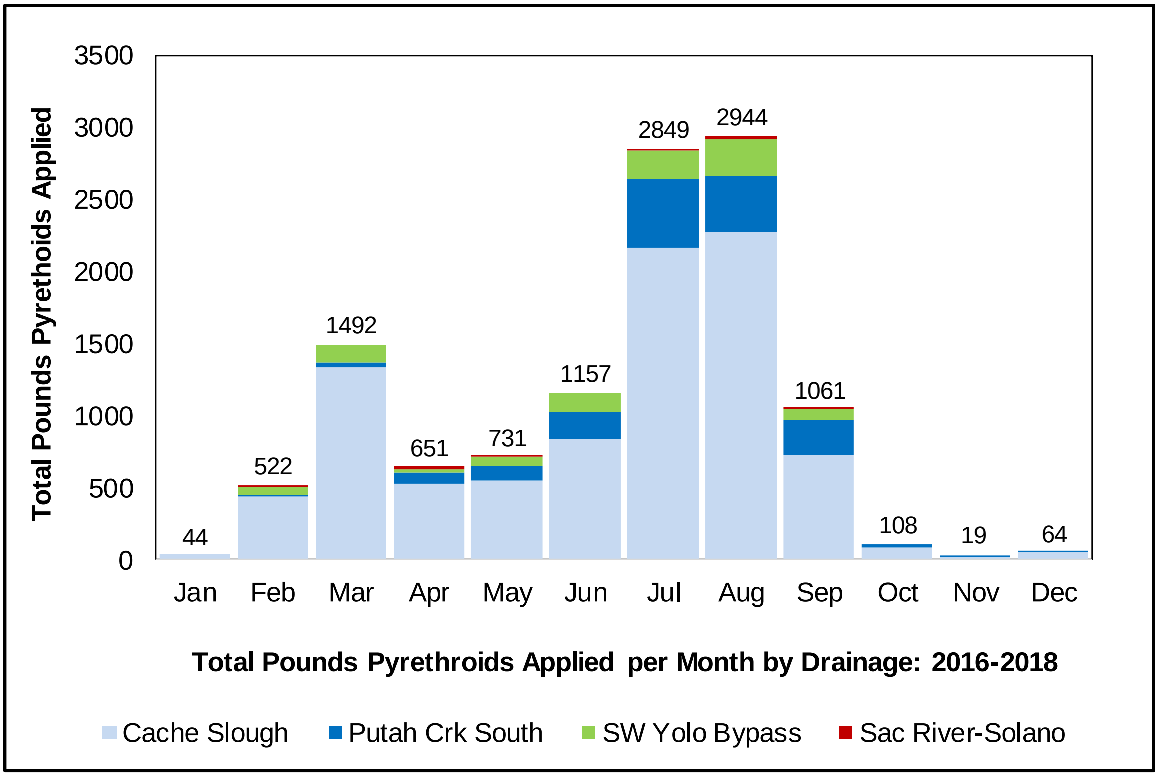


Figure B1: Total Pounds Pyrethroids Applied by Irrigated Agriculture per Month in Solano Subwatershed Drainages: 2016 – 2018.

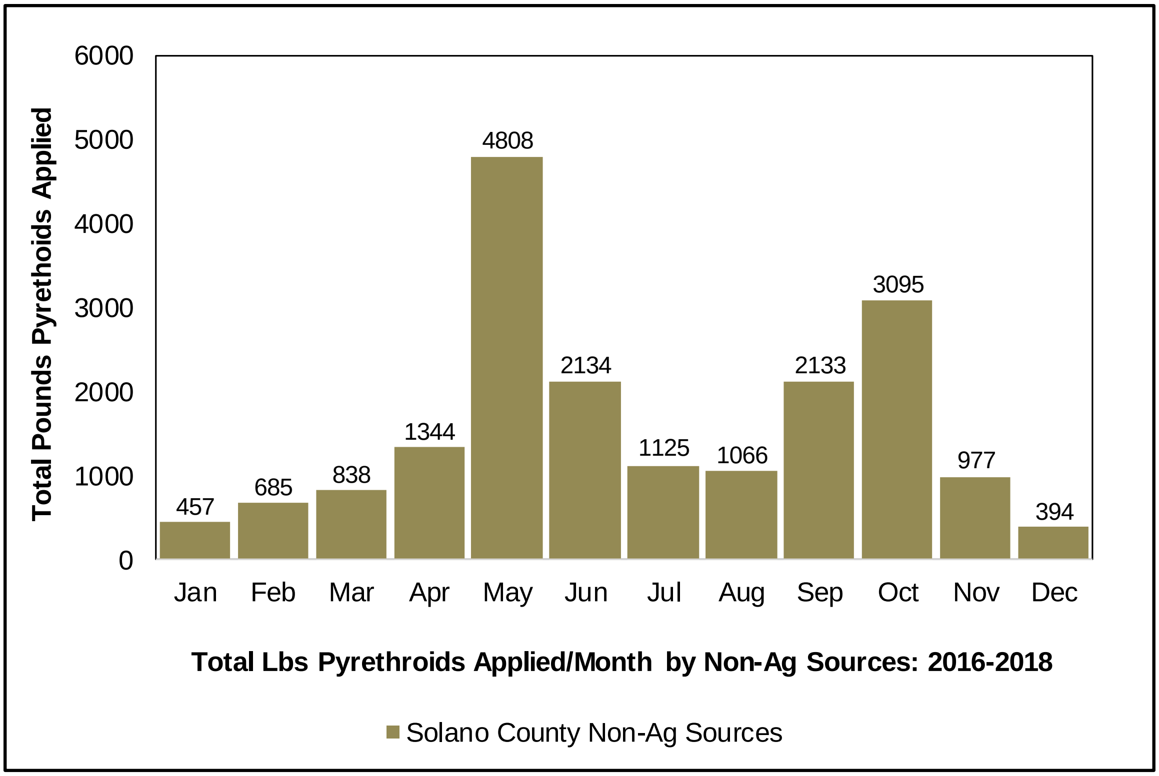


Figure B2: Total Pounds Pyrethroids Applied by Licensed Non-Agricultural Sources (DOES NOT include un-reported non-ag applications like residential uses) per Month in Solano County: 2016 – 2018.

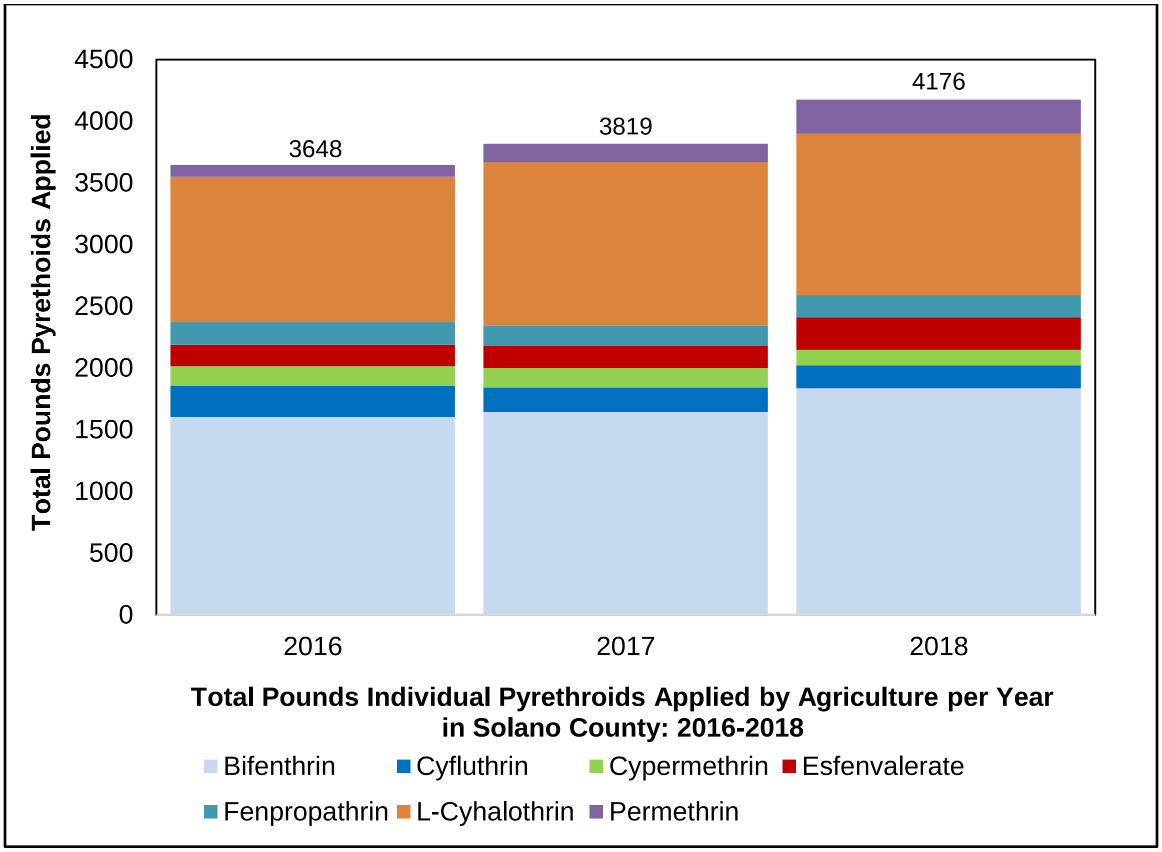
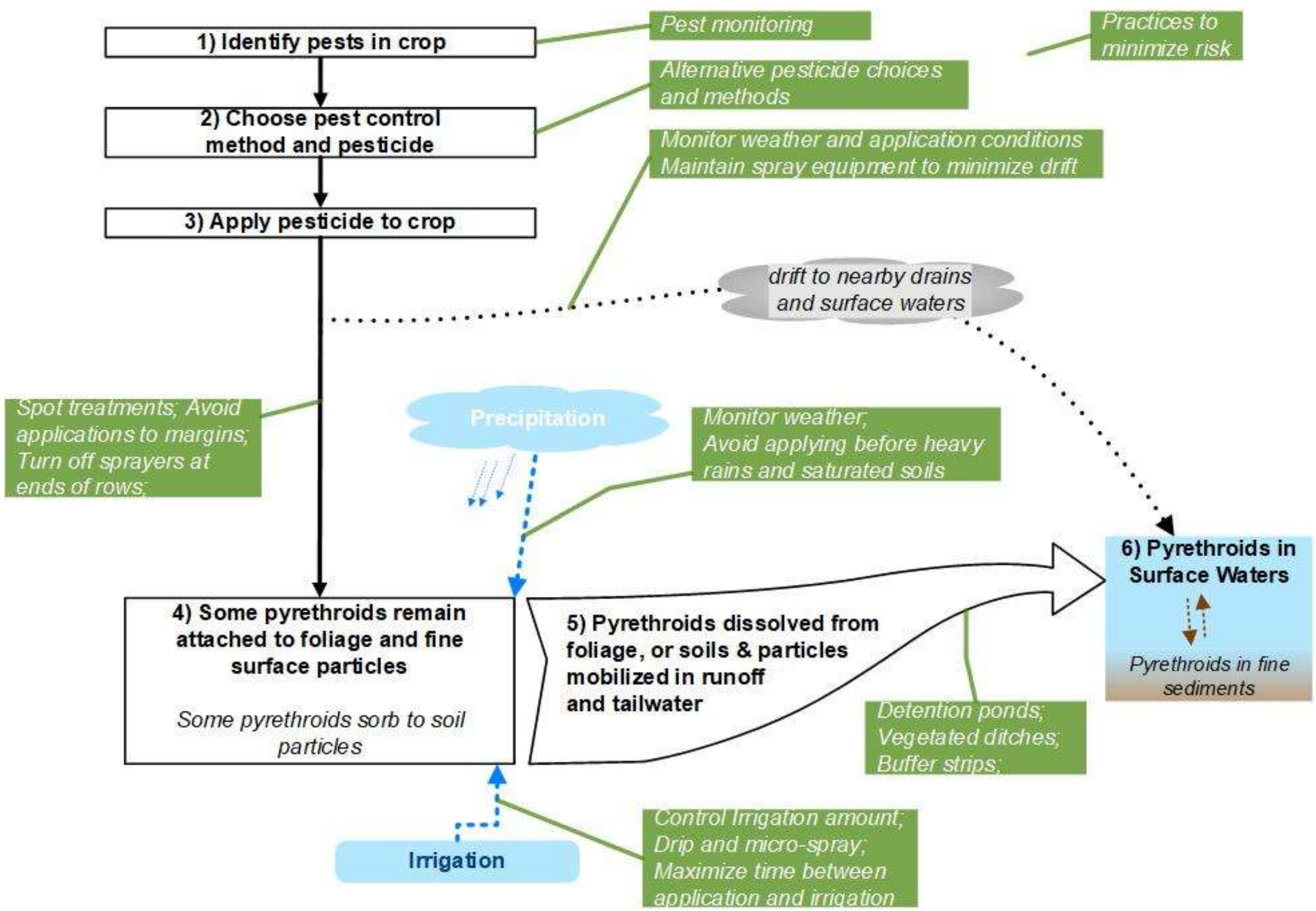


Figure B3: Total Pounds of Individual Pyrethroids Applied by Irrigated Agriculture per Year in Solano County: 2016 – 2018.

Appendix C: Pathways for Transport of Agriculturally Applied Pyrethroids to Surface Waters and Practices to Minimize Risk of Off-site Transport

Figure 1. Pathways for transport of agriculturally applied pyrethroid pesticides to surface waters and practices to minimize risk of pesticide transport



Appendix D: Pyrethroid Facts and Recommended Practices

Dixon/Solano RCD Water Quality Coalition
1170 North Lincoln St. Suite 110 • Dixon, CA 95630 • 707-678-1655
Coalition Contact: Kelly Huff, ext. 102

Pyrethroid

Product Types: esfenvalerate, lambda-cyhalothrin, gamma-cyhalothrin, bifentrhin, cypermethrin, permethrin, cyfluthrin

Products Include: Adjourn, Ammo, Asana XL, Athena, Baythroid, Bifenture, Bolton, Brigade, Capture, Cobalt, Fanfare, Hero, Karate, Lambda-Cy, Lambdastar, Lamcap, Leverage, Mustang, Paradigm, Pounce, Province, S-Fenvalostar, Silencer, Sniper, Stiletto, Warrior

Movement: High tendency to attach to fine soil particles. Moving with sediment in irrigation tailwater or stormwater and/or through application drift

Field Dissipation Half Life: Half-life in soils ranges from 1-2 months. In aquatic sediment, months to years.

Aquatic Toxicity Very high to Extremely High

CRITICAL USE ACTIVITIES: Spring and/or summer applications to various crops (including orchards, tomatoes, beans, peppers, alfalfa, corn, sudangrass)

RECOMMENDED PRACTICES

1) Consider Alternative Products & Integrated Pest Management Strategies (see UCCE Alternatives Products List or visit www.ipm.ucdavis.edu)

2) Where agricultural uses continue, implement one or more of the following:

- Use extreme caution during applications around **field edges.** Eliminate drift and overspray, especially near ditches (supply and drainage). Apply by ground whenever possible.
- Pay special attention to buffer zone & vegetated buffer requirements on label under **SPRAY DRIFT PRECAUTIONS.**
  - Irrigation management practices to reduce and/or slow tailwater runoff:
    * Drip or micro irrigation.
    * Monitor soil moisture levels and evapotranspiration rates in irrigation management.
  - Avoid applications of pyrethroids just prior to a rainfall event or irrigation to minimize the potential for runoff.
  - Sediment Retention (especially fines) with the following methods suggested:
    * Direct post-treatment runoff through filter strip, alfalfa field or vegetated drainage ditch.
    * Temporarily impound post-treatment runoff in a sediment basin (although basin sizes necessary to capture fine sediments may be impractical depending on site characteristics); sediment basin effectiveness can be increased by directing the basins outflow through a vegetated filter strip or vegetated ditch
    * Recirculate runoff through a tailwater return system.
    * Reduce and/or delay release of tailwater after application to allow product to degrade.
  - Install irrigation socks where gated pipes are used to minimize soil erosion.
  - Apply water-based Polyacrylamides (PAMs), after the first pyrethroid treatment post-cultivation.