Volume 1 of 1 of Submission

PROJECT TITLE

THE USE OF AGRICULTURAL SEDIMENT BASINS AND PAM AS BEST MANAGEMENT PRACTICES IN IRRIGATED TOMATOES

DATA REQUIREMENTS

None

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PROJECT COMPLETION DATE

July 22, 2008

Volume 1 of 1 Report

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Report Title: The Use of Agricultural Sediment Basins and PAM as Best Management Practices in Irrigated Tomatoes

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Member Companies: Bayer CropScience, Du Pont Agricultural Products, FMC Corporation, Pytech Chemicals GmbH, Valent USA Corporation, and Syngenta Ag

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Report Title: The Use of Agricultural Sediment Basins and PAM as Best Management Practices in Irrigated Tomatoes

Good laboratory practice requirements of 40 CFR Part 160 do not apply to the study described in this document.

Submitter: Pyrethroid Work Group (Consortium No.64977)

Member Companies: Bayer CropScience, Du Pont Agricultural Products, FMC Corporation, Pytech Chemical GmbH, Valent USA Corporation, and Syngenta Ag.

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EXECUTIVE SUMMARY

The use of polyacrylamide (PAM) and sediment basins have long been recognized as effective Best Management Practices (BMPs) for reducing sediment load in irrigated agriculture and this has been confirmed by many independent studies. Other effective sediment technologies have been demonstrated for CA conditions by local experts. By reducing sediment load there is also the potential for reducing residues of highly hydrophobic chemicals such as the pyrethroid insecticides which adhere to the sediment particles in irrigation tailwater.

This study examined transport of pyrethroids and sediment from tomato fields under two sets of conditions representing a wide range of sediment transport potential. The first (trial 1) was from runoff under typical high irrigation water flow rates from rows that were not treated with PAM during the trial – conditions prone to move larger and undesirable amounts of sediment into tailwaters. The second trial (trial 2) combined both low water flow rates and PAM treatment – conditions expected to transport reduced levels of sediment.

Quantification of TSS in water leaving the two trials showed, as expected, sediment transport levels that differed significantly. Approximate estimates suggest that trial 1 transported nearly 20 times as much sediment with approximately 1.5 times the volume of runoff leaving the plot.

The amount of pyrethroid transported was similar between trials with differences between the concentrations in runoff samples generally being within a factor of two (with values for trial 1 (high sediment transport) being generally higher than trial two). Early samples contained higher residues than later ones while the flow was typically lower at these earlier sampling periods. Approximate estimates of the mass transported from the trial plots showed the mass of pyrethroid transported in trial 2 was only around 40% of that transported in trial 1. The results suggest that pyrethroid residues on treated fields tend to be bound to the surface soil layer and transported under the conditions of both trials.

The data obtained from the trials show that the sediment basin was effective in reducing discharges of pyrethroids. Trial 1 (in which the sediment basin would be expected to be less effective due to the higher water velocity) showed a reduction in pyrethroids of about 80 percent (along with about 75 percent of the sediment).

This study has demonstrated that pyrethroid residues transport with a portion of the sediment that is eroded from the field under conditions of both high and low erosion potential. Importantly, the data also show that methods established to reduce water and sediment from the field (e.g. PAM and more careful irrigation flow control) and also technologies demonstrated to remove sediment from edge of field tail waters (e.g. sediment basins) are both effective in reducing pyrethroid transport in addition to their well documented benefits for reducing sediment transport.

This study has confirmed that methodologies that have been shown to reliably reduce erosion from fields and also to reduce sediment transport in tail waters will be an effective way of helping to control the transport of pyrethroids from agricultural fields to the irrigation return ditches in California. Next steps should include the promotion of these technologies in areas where irrigation tail water transport of sediment is known to occur.

1.0 INTRODUCTION

Previous research indicates that sediment basins can play an effective role in the reduction of sediment and pesticide runoff from agricultural fields. If sediment basins are designed correctly, they may trap up to 70-80% of the sediment that flows into them (see California Stormwater BMP Handbook, 2003). Compounds that are highly hydrophobic such as the organochlorine pesticides, polychlorinated biphenyls (PCBs) and polyaromatic hydrocarbons, and pyrethroids bind readily to the sediment and are removed from the runoff water as the sediment settles. Although a number of papers have investigated the transport of highly hydrophobic compounds into agricultural streams with the sediment (Pereira et al., 1995; van Metre et al., 1997), to date no data exist on the effectiveness of sediment basins for the removal of pyrethroid residues from agricultural runoff.

Polyacrylamide (PAM) is a water soluble, synthetic organic polymer. It has been used in agriculture for soil erosion control on about one million hectares worldwide (Sojka et al., 1998). It has also been used as a flocculent in municipal water treatment, paper manufacturing and food processing (Sojka and Lentz, 1997). PAM interacts with soil particles to stabilize both soil surface structure and pore continuity (DeBoodt, 1990; Malik and Letey, 1991). Under experimental field-trial conditions, proper application of PAM with the first irrigation has substantially reduced soil erosion in furrow systems with benefits that include reduced topsoil loss, enhanced water infiltration, improved uptake of nutrients and pesticides, reduced furrow-reshaping operations, and reduced sediment-control requirements below the field (Sojka and Lentz, 1996). By increasing soil flocculation, PAM has been shown to be effective in reducing sediment erosion through runoff and increasing water infiltration (Lentz et al., 1995). A recent study has found that PAM applications to furrow irrigated crops reduced sediment erosion by over 90 percent (Orts et al., 2007). As reductions in sediment runoff are achieved, reductions in pesticides such as dicofol that are highly absorbed to soil particles also occur (Singh et al., 1996). Broadcast applications of PAM were also found to be significantly effective in increasing water infiltration and reducing sediment runoff (Abu-Zreig, 2006).

This study examines the use of sediment basins with and without the use of PAM to reduce pyrethroid residues in agricultural runoff following a pyrethroid (lambda-cyhalothrin, structure shown in Figure 1) application to processing tomatoes at the rate of 0.02 lb ai/A. Data from this study will be used to evaluate the effectiveness of using these technologies as Best Management Practices (BMPs) in reducing the off-site movement of pyrethroids in irrigation tailwaters. The purpose of the study was not to repeat the body of research that has already confirmed the efficacy of PAM and sediment basins in reducing total suspended solids (TSS), but to learn more about how the pyrethroids behave with respect to the sediment in these systems.

2.0 METHODS AND MATERIALS

2.1 Study Site and Irrigation

The study was conducted on a 455-acre commercial farm field located near the city of Patterson, California (see Figure 2) in the San Joaquin Valley. The site lies on the western slope of the Coastal Range (western side of the San Joaquin Valley). A site diagram is provided in Figure 3. At the initiation of this trial, the field was divided into numerous blocks, 300 acres of which were planted in processing tomatoes with the balance in spinach and dry beans. The National Resource Conservation Service (NRCS) classified the soil type as primarily a Vernalis clay loam (94 % of the site) with the balance as Zacharias clay loam (6 %), which has been laser planed to 1-2 percent slope.

At the base of each field block is a sediment basin and sump to capture the irrigation drainage water (or tailwater) which is then directed to a master sump and sediment basin located in the northeastern corner of the field. Water in the master sump is then re-circulated by pumping the water back to the top of the field where fresh water is added to make up for any water lost during irrigation and evaporation.

The 65-acre block used for the trial (noted on Figure 3 with an enlarged view on Figure 4) was bedded up and transplanted with canning tomatoes on April 18, 2007 (Figures 6 and 7). The transplants were initially irrigated in 24-hour sets at least every seven days. The beds were cultivated on May 9, 2007 and June 25, 2007. As the plants reached approximately 18 inches in height and began to impede the flow of water in the furrows, the grower switched to a 12-hour set to prevent the beds from becoming too wet. The sediment basin when filled measured 127 feet in length and 30 feet in width. The depth was approximately 8 feet when full. Due to the irregular shape and depth, no estimate was made of the volume of water in the sediment basin when filled. At the end of the basin was a 9 ½-inch standpipe which acted as the field drain (see Figure 8). In the 65-acre block used for both trials described in this report (Figure 3), irrigation is applied to about 13 acres at a time (26 rows). The second trial was conducted in the northernmost 26 rows, and the first trial was conducted on the 26 rows just south of the rows used in the second trial. Irrigation is applied at the western end of the field (rows and irrigation furrows run west to east) with water introduced into an irrigation ditch that runs the length of the western edge of the field (see Figure 9). Siphons are used to remove water from the ditch and introduce water into the irrigation furrows. There is also an irrigation pipe running north-south through the field half-way between the east and west ends of the field. This pipe has simple gate valves built into the pipe so that when opened, water is introduced into the irrigation furrow.

Drainage water (tailwater) from all irrigation furrows in the 65 acre block empties into an interception ditch on the eastern end of the field (see Figure 5). This then drains into a ditch that generally flows northward into the sediment basin at the northeast corner of the block. At the northernmost section of the field, the ditch is just west of the sediment basin and water can flow into the sediment basin at either the south or northwest end. During the trials, the water was directed toward the southern end of the sediment basin.

To reduce erosion, the grower typically applies polyacrylamide (PAM) using the “patch method” at each irrigation event (including irrigation events that occurred prior to the application of the pyrethroid). The "patch method" involves placing PAM at the point in the furrow where the water first hits; applying it for a length of about 3-5 feet down the furrow to reduce the risk of the PAM becoming buried in the furrow or washing down the furrow with little to no effect. The patch method creates a sort of gel-slab at the top of the furrow where the water slowly dissolves the PAM and carries it down the furrow. An example of the PAM being applied in field is shown in Figure 9. (The grower has indicated that without the use of PAM, he would have to constantly excavate his sediment basins due to the highly erodible soil. In addition to the cost of excavation, he would have to re-laser and re-level his field beds. He has calculated that he spends approximately $7/acre for PAM each year which he considers a minor investment for the benefits obtained.)

2.2 Climate

Climate in the vicinity of the project is typical for the central San Joaquin Valley. Two seasons dominate: winters with cool temperatures and periods of rainfall (November through April) and summers with high temperatures and minimal to no rainfall. Data retrieved from the closest California Irrigation Management Information System (CIMIS) Weather Station (#161) in Patterson, CA indicated no precipitation during the time from the application of the pyrethroid through the end of the study (July 13-July 18, see Table 1) with a maximum temperature of 89.0 ^{o}F and a minimum temperature of 53.6 ^{o}F (see Table 2).

2.3 Application of Lambda-Cyhalothrin

Lambda-cyhalothrin is typically applied to tomatoes in this region several times during the irrigation season to control worms and chewing insects. In this study, lambda-cyhalothrin was applied by air as Warrior® with Zeon Technology™ at the rate of 0.02 lb ai/A on the morning of July 15, 2007. The entire block of 65 acres was treated for a total target mass of 1.3 lbs ai applied (0.26 lb ai per irrigation section).

2.4 Study Design

This study consisted of two sequential trials:

- The use of a sediment basins alone without the use of PAM
- The use of the same sediment basin, in combination with applications of PAM

In the first trial, rows 27-52 (number 1 is the northernmost row of the block) were irrigated but no PAM was applied. Supplemental irrigation was also added at the middle of the field. The tailwater from each furrow was collected in a drainage ditch that passed over a weir (Figure 10) and then discharged into the southern end of the sediment basin. Duplicate 250 mL samples (one for pyrethroid analysis and one for TSS) of drainage water were taken every hour at the entrance of the sediment basin. Once water began to flow out of the sediment basin, samples were collected hourly at the exit of the sediment basin (Table 1)

In the second trial, rows 1-26 were irrigated and approximately one cup of PAM was applied (Figure 9) to the western end of each furrow (Figure 4) where the irrigation water enters the field. Due to unexpected water use restrictions, No irrigation water was added from the pipe at the middle of the field. The product used was Soil Fix IR (CIBA Specialties) which contains 90% PAM. Duplicate 250 ml samples of drainage water were taken every two hours at the entrance and exit (upon initiation of flow) of the sediment basin. The longer sampling intervals in this trial were due to the lower flows observed (see Results and Discussion).

2.5 Flow Measurements

A rectangular weir was installed in the ditch as shown in Figure 10. The weir had a crest length of 1.583 ft. The height of the water over the weir was measured at various intervals during the study. The weir was slightly slanted which caused one side of the weir to have water height slightly higher than the other side. Therefore, an average height was used to calculate flow. The flow was calculated using the rectangular weir equation (Brater and King, 1982):

$$Q=3.33LH^{3/2}$$

where Q is the flow in cfs, L is crest length in ft, and H is the height of the water (head) relative to the crest (weir).

2.6 Sample Containers

Teflon-FEP containers were selected for use in this study, based on the work of Robbins (1997) which shows a recovery of lambda-cyhalothrin of 89 percent after 57 days.

2.7 Sample Collection

Tailwater samples were sampled either by hand or with a pole sampler (Wildco 12-foot swing sampler, 165-C10) every 1 or 2 hours from a weir located in the ditch draining the tailwater prior to entering the sediment basin (see Figure 10) and from the field drain at the end of the sediment basin (see Figure 5 and 8). Note that samples at the exit of the sediment basin could not be taken during the initial sample intervals of both trials, as the basin had not filled up and therefore was not discharging. At each sampling interval, a sample of approximately 250 mL was collected for pyrethroid analysis in a 500mL Teflon-FEP bottle (Fisher Scientific, A71841099) and another sample of approximately 250 mL was collected for measuring total suspended solids in a 500 mL Nalgene polypropylene bottle (Fisher Scientific, A71841086). Within five minutes of collection, the samples were placed in a cooler filled with ice prior to delivery to the analytical laboratory. Samples were kept on ice in the ice chests for a maximum period of 7 days prior to delivery to the analytical laboratory where they were immediately placed in refrigerators for storage until extraction.

2.8 Sample Analysis-Pyrethroids

All samples were delivered to Morse Laboratories, Inc in Sacramento, California for analysis. Samples were extracted within 18 days and analyzed using a slight modification of the analytical method (Pyrethroid Working Group, 2007) within 22 days of receipt.

To extract samples prior to lambda-cyhalothrin analysis, 100 mL of MeOH and 25 mL of hexane were added to each sample bottle. The samples were shaken on a mechanical shaker for approximately 10 minutes and the solvent layers were allowed to separate. A 5.0 mL aliquot of the upper hexane layer was transferred to a test tube (13 x 100 mm) and concentrated to ~0.2 mL using an N-evap evaporator set to ≤40°C. The samples were manually evaporated to dryness with nitrogen. To each sample, 2.0 mL hexane were added, mixed well and sonicated. The sample was transferred to a 500 mg Varian Silica Bond Elut solid phase extraction cartridge with a 1.0 mL rinse of hexane. The cartridge was eluted under gravity or low volumetric pressure and the eluate discarded. A 10 mL collection tube was placed under each cartridge and the cartridge was eluted with 6 ml of a hexane/diethyl ether [9:1, v/v] solution. The eluate was concentrated to dryness under a stream of dry, clean air in a heating block set to 40°C. The sample was redissolved in acetone +0.1% peanut oil solution with ultrasonication. The sample was transferred to an autosampler vial for final determination by GC-MSD/NICI.

Note: The 0.1% peanut oil in acetone solution is used to minimize the effect of matrix related to GC-MSD response enhancement and to minimize possible peak tailing due to adsorption.

Final Determination by GC-MSD

The following instrument and conditions have been found to be suitable for analysis. Other instruments can also be used, however optimization may be required to achieve the desired separation and sensitivity.

Instrument Conditions

GC system	:	Agilent 6890 with split/splitless injector
MSD system	:	Agilent 5973 with negative ion chemical ionization
Injection temperature	:	275°C
Injection liner	:	4 mm i.d. double gooseneck splitless liner (unpacked)
Column	:	Varian CPSil 8 30 m × 0.25 mm, 0.25 µm film thickness (5% diphenyl, 95% dimethylpolysiloxane)
Column flow rate	:	0.9 mL min^{-1} constant flow
Injection mode	:	Pulsed splitless, 30 psi for 1 min, purge flow to split vent 50 psi @2 min
Injection volume	:	2 µL
Column temperature program	:	80°C for 1 min then program at 40°C/min to 180°C, hold for 0 min then program at 5 °C/min to 305 °C, hold for 0 min.

Under these conditions, lambda-cyhalothrin has retention times of 19.6 and 19.9 minutes for the two resolved diastereomers.

2.9 Sample Analysis-Total Suspended Solids

The analysis of tailwater samples for Total Suspended Solids (TSS) was based on Method 2540 D "*Total Suspended Solids Dried at 103-105^{o}C*" as described in Standard Methods for Examination of Water and Wastewater (18th Edition, 1992).

The glass fiber filter and planchet were weighed prior to filtration. The filter disk was inserted into the filtration apparatus. The sample of tailwater water was added to the filter and rinsed with three successive 10 mL portions of reagent grade water. Allow continuous suction for about 3 minutes after filtration is complete. The filter and planchet were removed from the filtration unit and dried in an oven at 103 to 105^{o}C for one hour. The sample was cooled in a desiccator to balance temperature and weighed. This cycle of drying, desiccation and weighing was repeated until a constant weight is obtained. The total mg of suspended solids in each sample was calculated using the following formula.

mg total suspended solids/sample = (weight of filter + dried residue) – (weight of filter)

2.10 Calculation of Water, Sediment, and Pyrethroid Discharges

Amounts of water, suspended solids, and pyrethroids entering and leaving the sediment basin were calculated by performing a numerical integration. This numerical integration assumed that the flow of tailwater into the basin was zero at the time of the first sample (the first sample was taken just as flow began to start) and then varied linearly between flow measurements. Water flow out of the sediment basin was assumed to be equal to the flow of water into the basin during times when the basin was discharging. This assumption may overestimate the amount of material leaving and underestimate of TSS and pyrethroid reductions since other processes (for example, infiltration and evaporation) were assumed not to be significant. In the second trial the flow was assumed to be constant after the last flow measurement since all rows were discharging at that time. TSS and pyrethroid concentrations were assumed to vary linearly between sample times. Therefore, water flow rates and concentrations of TSS and pyrethroids could be estimated at one minute intervals using these assumptions. The numerical integration was performed using a one minute time step. The amount of tailwater flow during each minute was estimated using the average volumetric flow rate during the minute (flow at the start of the minute plus flow at the end of the minute divided by two). Amounts of TSS and pyrethroid mass for each minute were estimated by multiplying the amount of water flow for each minute times the average concentration (concentration at the start of the minute plus concentration at the end of the minute divided by two). The tailwater flows and amounts of TSS and pyrethroid for each minute were summed over appropriate study intervals.

3.0 RESULTS AND DISCUSSION

3.1 Flow Rates

During the study considerable variability in the onset of runoff and the drainage flows occurred between trials and among irrigation furrows within a trial. This variability must be considered in the interpretation of the study results.

In the first trial, irrigation water reached the bottom (east end) of the irrigation furrows approximately 2-3 hours after the irrigation was started. Starting the irrigation in the various furrows at the end of the field was not an instantaneous process, but required approximately an hour to set the siphons at the west end and turn on the gate valves in the middle of the field. At the time the water in the drainage ditch reached the weir at the inlet to the sediment basin and sampling began, water from only 3 of 26 furrows had reached the end of the row and was contributing to tailwater flow. Two hours later, only 14 of the 26 furrows were draining into the ditch leading to the sediment basin. Five hours after the start of sampling, all but three of the furrows were draining. However, the final furrow did not start draining until about ten hours after the first furrows began draining. This resulted in increasing flow rates through the weir during the majority of the trial (Figure 11).

Between the 9 and 10-hour samples, a stream of water was observed entering the northern side of the sediment basin (see Figure 5). The water level in the irrigation ditch at the west side of the block had been slowly rising during the night and had begun to flow over the ditch bank into row 1 at the northern end of the ditch. Therefore, the measurements at the weir no longer represented the discharge out of the sediment basin and the concentration of TSS and pyrethroids in the second stream were unknown. As a result, the interpretation of the study results was based on the data collected through nine hours, although the data from the later time intervals have been included in the figures and tables.

The intent was to conduct the second trial with flow rates similar to those used in the first trial. However, due to water restrictions, less water was available for the second trial than for the first trial so no additional irrigation water could be added at the middle of the field. In the first trial, tailwater flow rates peaked at about 800 L/min, while the peak tailwater flow in the second study was only about 30 percent of that in the first trial. Therefore, the second trial provides information about the operation of the sediment basins under quite different operating conditions. First the sediment basin in the second trial was nearly full of water and contained TSS and pyrethroids from the first trial. Second, as mentioned earlier the flow rates in the second trial were only about 30 percent of that observed in the first trial. As a result, conclusions can not be drawn about the percent reduction in TSS or pyrethroids resulting from the use of PAM alone.

In the second trial about five hours was required between the start of irrigation and the onset of tailwater discharge into the ditch leading to the sediment basin. The pattern of increasing flow in the second trial was similar to that observed during the first trial, with all 26 rows contributing to tailwater after about 10 hours. At the same time as the 14-hour samples were collected, the tailwater ditch began to overflow and flood the access road, so the western entrance into the sediment basin had to be opened. Water entering via the western entrance bypassed the weir (see secondary channel in Figure 5). Therefore, the study results were interpreted based on the data collected through 14 hours. However, the calculations were also performed for the 16-hour period assuming no change in flow rate and there was no significant different in the performance of the sediment basin for removal of pyrethroids.

3.2 Lambda-Cyhalothrin Residues and Total Suspended Solids (TSS)

The concentration of lambda-cyhalothrin (expressed in ug/L) and TSS levels (expressed in mg/L) for each runoff sample can be found in Tables 3 and 4. Pyrethroid analyses are presented graphically in Figures 12 and 13.

With each set of analyses for lambda-cyhalothrin, two untreated water samples were fortified at two different rates to validate the analytical set. The average recovery of lambda-cyhalothrin was 108 ± 11.7% over the course of the study (see Table 5). The Limit of Determination (LOD) for the analytical method was 0.01 ug/L.

Concentration of both pyrethroids and TSS appears to be spiky. This is probably the result of the flush that occurs when new rows begin to deliver tailwater and associated TSS and pyrethroid residues.

Lambda-cyhalothrin residue levels in the runoff samples from the study conducted without adding PAM to the irrigation runoff (Table 3) ranged from 2.005 down to 0.191 ug/L at the field exit (prior to entering the sediment basin) and 0.135 down to 0.102 at the exit of the sediment basin. At the same time, the levels of total suspended solids ranged from 860 mg/L down to 390 mg/L prior to entering the sediment basin and 535 mg/L down to 85 mg/L at the exit of the sediment basin. The results show a decline in TSS and pyrethroid concentrations during the time the sediment basin was discharging. Also the maximum concentrations observed in the inlet are higher than in the outlet stream.

The pattern of results is slightly different for the second trial. Pyrethroid concentrations in the runoff samples from the study conducted with PAM added to the irrigation water (Table 4) were lower and ranged from 1.32 down to 0.106 ug/L at the entrance to the sediment basin and 0.144 down to 0.0416 ug/L at the exit of the sediment basin. In this case maximum pyrethroid concentrations in the inlet and outlet streams are significantly different and there also appears to be a reduction in concentrations during the time the sediment basin is discharging. However, the concentrations of TSS are largely unchanged between the inlet and outlet streams over the entire test period (although there is variability in the concentrations of both streams).

3.3 Estimation of Efficiency for Removing Residues

Using the flow measurements and the concentrations of TSS and pyrethroids, the amount of water, TSS, and pyrethroids entering and leaving the sediment basin were calculated as a function of time using the numerical integration process described earlier. The results of these calculations are presented in Tables 6 and 7.

The information in Tables 6 and 7 can be used to estimate the removal of TSS and pyrethroids.

- Trial 1 transported nearly 20 times as much TSS in approximately 1.5 times the volume of runoff compared to Trial 2.
- In the first trial about 0.11 percent of the pyrethroid applied to the 15 acre irrigation section was transported into the sediment basin. In the second trial approximately 0.043 percent of the pyrethroid was transported (over 16 hours) or about 40 percent of the amount in Trial 1.
- 75 to 84 percent of the TSS and pyrethroid, respectively, were retained in the sediment basin in trial 1.
- In trial 2, concentrations of pyrethroids were lower in the outflow than the inflow and approximately 80-85 percent of pyrethroid was retained in the sediment basin.
- In trial 2, the differences in TSS levels flowing into and out of the sediment basin were too small and variable to allow reliable estimates of retention of sediment in the basin.

These results are consistent with other published data on sediment basins. Interpretation of these results requires consideration of factors such as :

- Starting volume of water in the sediment basin
- Initial pyrethroid content from earlier runoff events
- Starting TSS content
- Volumetric flow of streams into and out of the sediment basin

4.0 CONCLUSIONS

This study has demonstrated that pyrethroid residues transport with a portion of the sediment that is eroded from the field under conditions of both high and low erosion potential. Importantly, the data also show that methods established to reduce water and sediment from the field (e.g. PAM and more careful irrigation flow control) and also technologies demonstrated to remove sediment from edge of field tail waters (e.g. sediment basins) are both effective in reducing pyrethroid transport in addition to their well documented benefits for reducing sediment transport.

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6.0 ACKNOWLEDGEMENTS

The author wishes to thank Dr. Russell Jones (Bayer CropScience) and Dr. Paul Hendley (Syngenta) for their expert technical advice and assistance in the conduct of this study. In addition, sincere gratitude is expressed to the Pyrethroid Working Group (PWG) for their financial support to the Coalition of Urban/Rural Stewardship (CURES) for the execution of this project. Without this generous support of both time and money, this project would not have been possible.

7.0 TABLES AND FIGURES

Table 1. Timing of Major Study Events

Date/Time	Event
4/18/07	Bedding and transplanting
5/09/07	Beds cultivated
6/25/07	Beds cultivated
7/15/07 10 am	Application of pyrethroid
7/16/07 1:20 pm	Start of irrigation for Trial 1
7/16/2007, 2:20 pm	Collection of Pre-Irrigation sediment basin water sample prior to Runoff for Trial 1
7/16/07 4:59 pm	Collection of 0-hour sample (inflow)
7/16/07 4:65 pm	Water begins flowing into the sediment basin
7/16/07 9:59 pm	Outflow from sediment basin begins Collection of 5-hour samples (inflow and outflow)
7/17/07 2:22 am	Flow from second channel into the northern entrance to the sediment basin begins
7/1707 4:00 am	Completion of Trial 1
7/17/07 noon	Start of irrigation for Trial 2
7/17/08 6:28 pm	Water begins flowing into the sediment basin
6:41 pm	Collection of 0-hour sample (inflow)
7/18/07 12:41 am	Outflow from sediment basin begins Collection of 6-hour samples (inflow and outflow)
7/18/07 8:35 am	Second channel via the northern entrance into sediment basin opened
7/18/08 11:00 am	Completion of Trial 2

Table 2. Weather Data from CIMIS 161 (Patterson) for the Period 7/13/07-7/18/07

Daily Report

California Irrigation Management Information System
Department of Water Resources
Office of Water Use Efficiency
Rendered in ENGLISH units
July 13, 2007 - July 18, 2007
Printed on January 27, 2008

San Joaquin Valley - Patterson - 161

Date	CIMIS ETo (in)	Precip (in)	Sol Rad (Ly/day)	Avg Vap (mBars)	Max Air Temp (°F)	Min Air Temp (°F)	Avg Air Temp (°F)	Max Rel Hum (%)	Min Rel Hum (%)	Avg Rel Hum (%)	Dew Pt (°F)	Avg wSpd (MPH)	Wnd Run (miles)	Avg Soil Temp (°F)
07/13/07	0.24	0.00	609	14.9	87.1	55.3	71.8	83	38	56	55.2	5.0	119.7	81.1
07/14/07	0.26	0.00	609	14.2	89.0	58.7	73.7	81	28	50	53.9	5.9	142.5	81.4
07/15/07	0.27	0.00	604	13.7	88.9	57.5	74.1	75	29	48	53.0	5.7	138.7	81.3
07/16/07	0.24	0.00	595	13.8	83.9	58.1	71.2	76	33	53	53.1	5.0	121.1	81.4
07/17/07	0.23	0.00	607	13.8	82.4	53.6	68.9	82	39	57	53.2	4.7	113.5	81.0
07/18/07	0.20	0.00	528	16.3	80.2	58.8	69.5	85	52	66	57.7	6.3	150.9	81.0
Tot/Avgs	1.44	0.00	592	14.4	85.2	57.0	71.5	80	37	55	54.3	5.4	131.1	81.2

Flag Legend

A - Historical Average	I - Ignore	R - Far out of Normal Range
C or N - Not Collected	M - Missing Data	S - Not in Service
H - Hourly Missing or Flagged	Q - Related Sensor Missing	Y - Moderately Out of Range

Conversion Table

W/sq.m = Ly/day / 2.065	inches * 25.4 = mm
C = 5/9 * (F - 32)	m/s = mph * 0.447
kPa = mBars * 0.1	

Table 3. Analytical Data from Trial 1 (Sediment Basin without the use of Polyacrylamide (PAM))

Sample Number	Location	Interval	Volume	TSS (mg/L)	Residue (ug/L)
LCYH-07-100	Inflow	Pre-event*	2 L		<0.01
LCYH-07-101	Inflow	0 Hr	250 ml	390	2.005
LCYH-07-102	Inflow	1 Hr	250 ml	860	1.006
LCYH-07-103	Inflow	2 Hr	250 ml	850	1.632
LCYH-07-104	Inflow	3 Hr	250 ml	885	0.464
LCYH-07-105	Inflow	4 Hr	250 ml	655	0.523
LCYH-07-106	Inflow	5 Hr	250 ml	590	0.646
LCYH-07-107	Inflow	6 Hr	250 ml	625	0.33
LCYH-07-108	Inflow	7 Hr	250 ml	450	0.31
LCYH-07-109	Inflow	8 Hr	250 ml	515	0.348
LCYH-07-110	Inflow	9 Hr	250 ml	470	0.338
LCYH-07-111	Inflow	10 Hr	250 ml	465	0.673
LCYH-07-112	Inflow	11 Hr	250 ml	410	0.191
LCYH-07-114	Outflow	5 Hr	250 ml	475	0.135
LCYH-07-115	Outflow	6 Hr	250 ml	535	0.128
LCYH-07-116	Outflow	7 Hr	250 ml	125	0.131
LCYH-07-117	Outflow	8 Hr	250 ml	85	0.177
LCYH-07-118	Outflow	9 Hr	250 ml	130	0.102
LCYH-07-119	Outflow	10 Hr	250 ml	125	0.105
LCYH-07-120	Outflow	11 Hr	250 ml	160	0.105

* This sample was taken on the afternoon of the study but prior to any water entering the sediment basin.

Table 4. Analytical Data from Trial 2 (Sediment Basin with Polyacrylamide (PAM))

Sample Number	Location	Interval	Volume	TSS (mg/L)	Residue (ug/L)
LCYH-07-121	Inflow	0 Hr	250 ml	130	1.32
LCYH-07-122	Inflow	2 Hr	250 ml	45	0.369
LCYH-07-123	Inflow	4 Hr	250 ml	30	0.415
LCYH-07-124	Inflow	6 Hr	250 ml	25	0.963
LCYH-07-125	Inflow	8 Hr	250 ml	30	0.0947
LCYH-07-126	Inflow	10 Hr	250 ml	40	0.106
LCYH-07-127	Inflow	12 Hr	250 ml	25	0.162
LCYH-07-128	Inflow	14 Hr	250 ml	130	0.474
LCYH-07-129	Inflow	16 Hr	250 ml	45	0.247
LCYH-07-132	Outflow	6 Hr	250 ml	30	0.0605
LCYH-07-133	Outflow	8 Hr	250 ml	25	0.0416
LCYH-07-134	Outflow	10 Hr	250 ml	30	0.144
LCYH-07-135	Outflow	12 Hr	250 ml	130	0.0645
LCYH-07-136	Outflow	14 Hr	250 ml	40	0.045
LCYH-07-137	Outflow	16 Hr	250 ml	20	0.0605

Table 5. Lambda-Cyhalothrin Analytical Recovery from Fortified Basin Water Samples

Sample ID	Fort.Level (ug/L)	Recovered (ug/L)	% Recovery
1386A Fort. Control 8	0.01	0.0108	108
1386A Fort. Control 9	0.5	0.5423	108
1386B Fort. Control 10	0.01	0.0117	117
1386B Fort. Control 11	0.5	0.6085	122
1386B Fort. Control 12	0.01	0.0111	111
1386B Fort. Control 13	5	5.7733	115
1386B Fort. Control 14	0.01	0.0086	86
1386B Fort. Control 15	5	4.86	97
		Average	**108±11.6**

Table 6. Summary of Calculated Flows for Trial 1 (no PAM)

Time Period (hours)	Water Flow (L)	TSS (kg)		Pyrethroids (g)	
		Into Basin	Out of Basin	Into Basin	Out of Basin
0-1	4,000	3	-	0.006	-
1-2	13,000	11	-	0.017	-
2-3	20,000	17	-	0.020	-
3-4	24,000	18	-	0.012	-
4-5	28,000	18	-	0.017	-
5-6	32,000	19	16	0.015	0.0041
6-7	35,000	19	11	0.011	0.0045
7-8	38,000	18	4	0.013	0.0059
8-9	41,000	20	4	0.014	0.0058
9-10	45,000	21	-	0.023	-
10-11	46,000	20	-	0.020	-
Total 0-9	235,000	144	36	0.125	0.0204

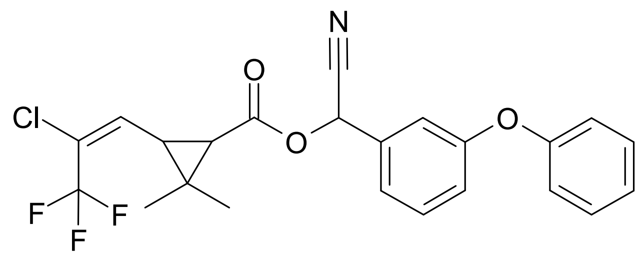
Water flow for 9-10 and 10-11 hours does not include the contribution of the second stream to sediment basin inflow or outflow. The TSS and pyrethroid flows into the basin for these same sample intervals do not include the contribution from the second stream.

Table 7. Summary of Calculated Flows for Trial 2 (with PAM)

Time Period (hours)	Flow (L)	TSS (kg)		Pyrethroids (g)	
		Into Basin	Out of Basin	Into Basin	Out of Basin
0-2	4,000	0.33	-	0.0031	-
2-4	10,000	0.37	-	0.0039	-
4-6	15,000	0.41	-	0.0104	-
6-8	19,000	0.52	0.52	0.0097	0.0010
8-10	23,000	0.81	0.63	0.0023	0.0022
10-12	26,000	0.84	2.07	0.0035	0.0027
12-14	26,000	2.01	2.20	0.0082	0.0014
14-16	26,000	2.27	0.78	0.0093	0.0014
Total 0-14	123,000	5.28	5.43	0.0412	0.0072
Total 0-16	149,000	7.54	6.20	0.0505	0.0086

Values for 14-16 hours assume that the total flow into the sediment basin remained constant and that the concentrations of pyrethroids and sediment in both streams entering the sediment basin were the same.

Figure 1. Chemical Structure of Lambda-Cyhalothrin



Chemical Structure for Lambda-Cyhalothrin

(1α(*S**),3α(*Z*)]-(±)-cyano(3-phenoxyphenyl)methyl 3-(2-chloro-3,3,3-trifluoro-1-propenyl)-2,2-dimethylcyclopropanecarboxylate)

Figure 2. Map showing location of Project Area-Patterson, California

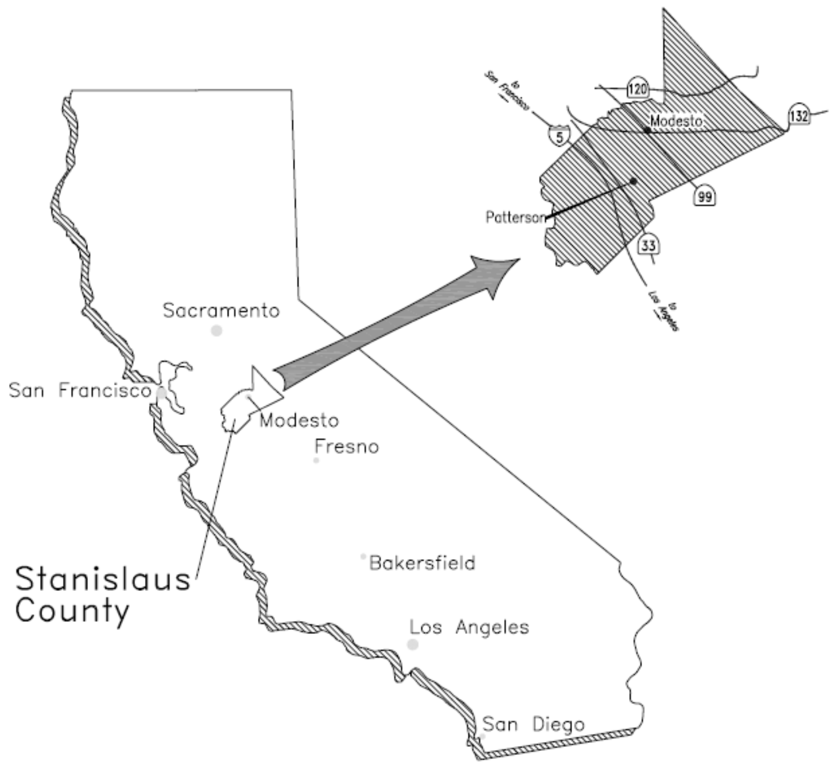


Figure 3. Site Diagram Showing Location of Sediment Basins (Field Sumps) and Recirculation System. The 65-Acre Tomato Field was used for the Study

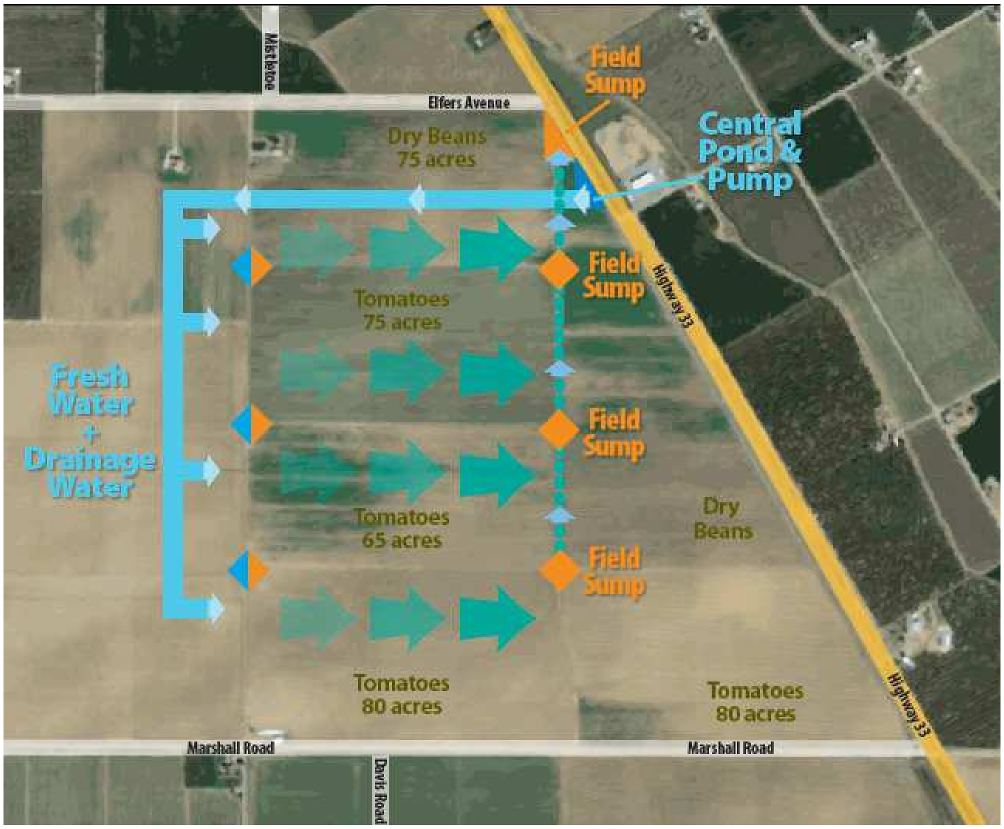


Figure 4. Enlarged Diagram of the 65-acre Block in which the Trials were Conducted

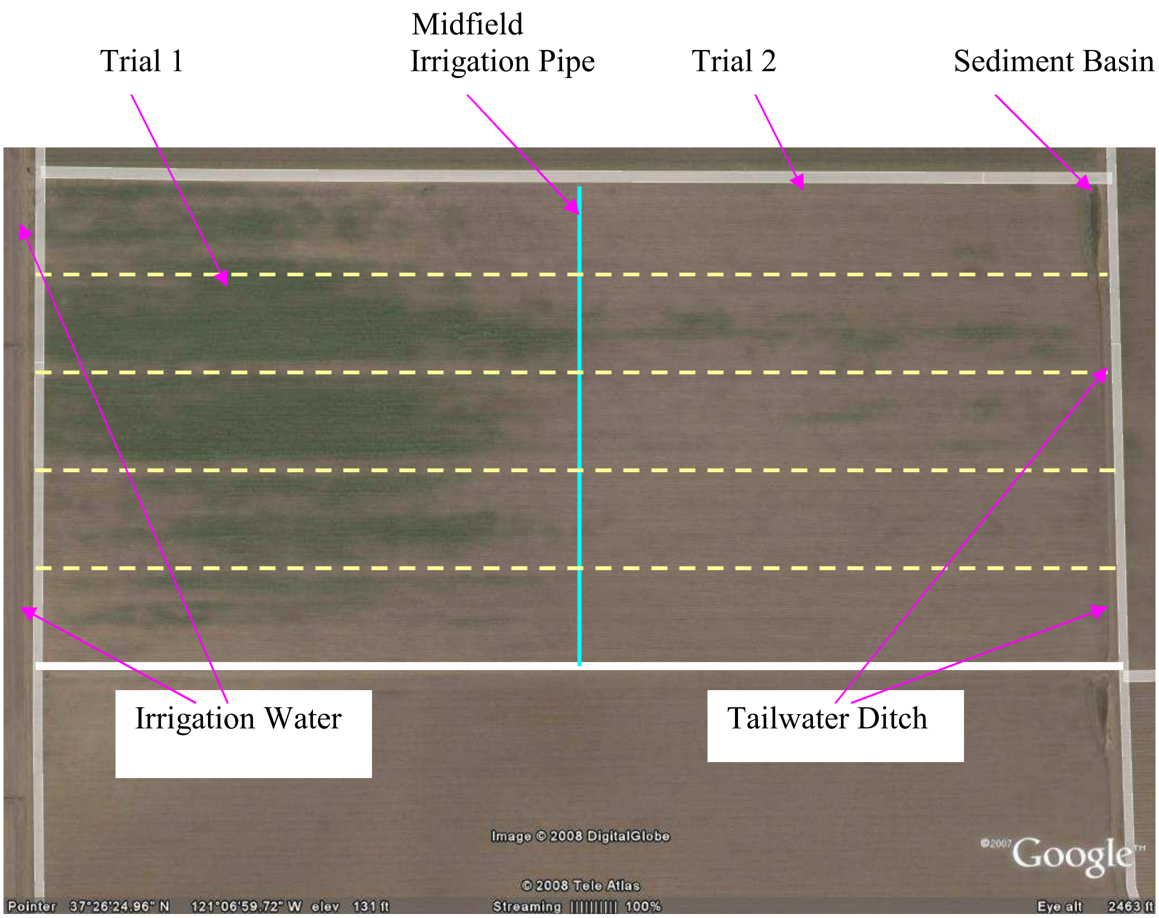
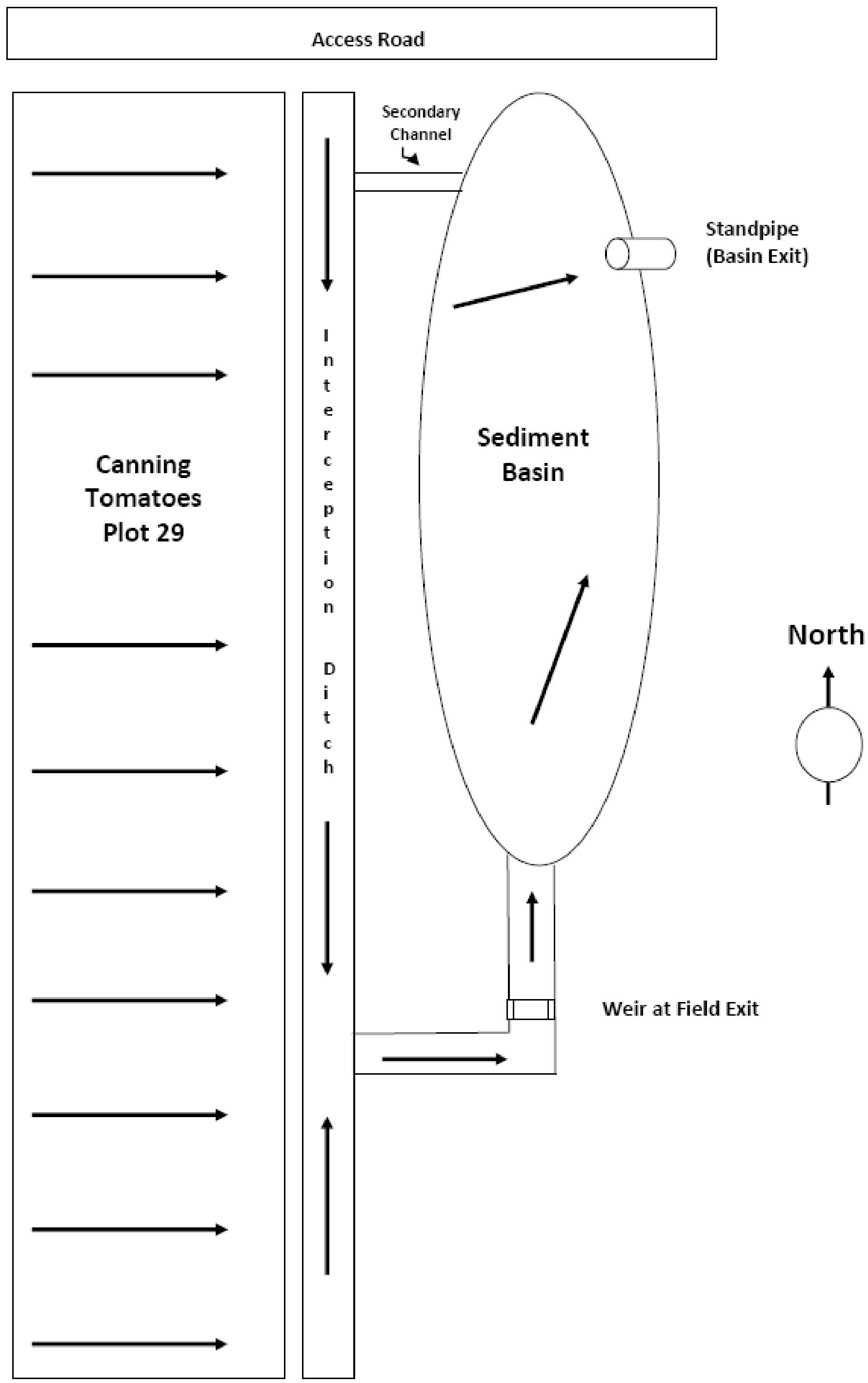


Figure 5. Plot Diagram for Sediment Basin Study



Arrows show primary direction of water flow

Figure 6.Tomato Field prior to the Start of the Study

Figure 7. Looking over the Sediment Basin towards the Tomato Field

Figure 8. Field Drain at end of Sediment Basin

Figure 9. Applicator Applying PAM to the Irrigation Row

Figure 10. Sampling of Weir Located at Edge of Field and prior to the Sediment Basin

Figure 11. Flows Measured at the Weir during the Trials.

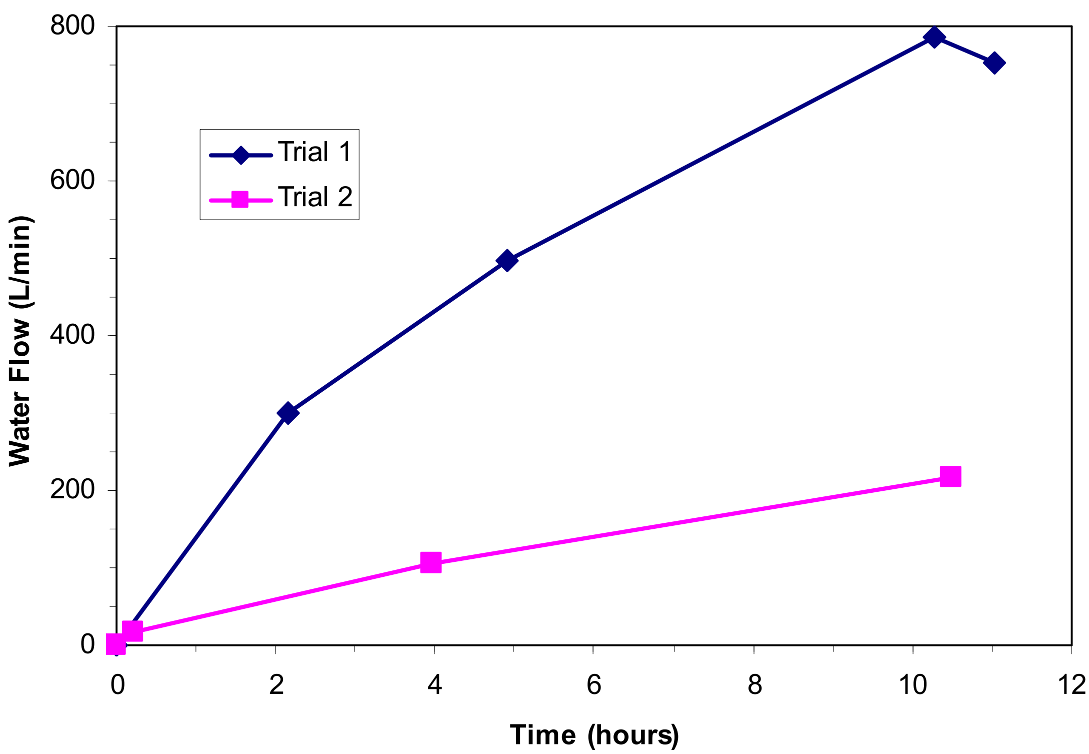


Figure 12. Pyrethroid Residues in Runoff Samples Without PAM Treatment

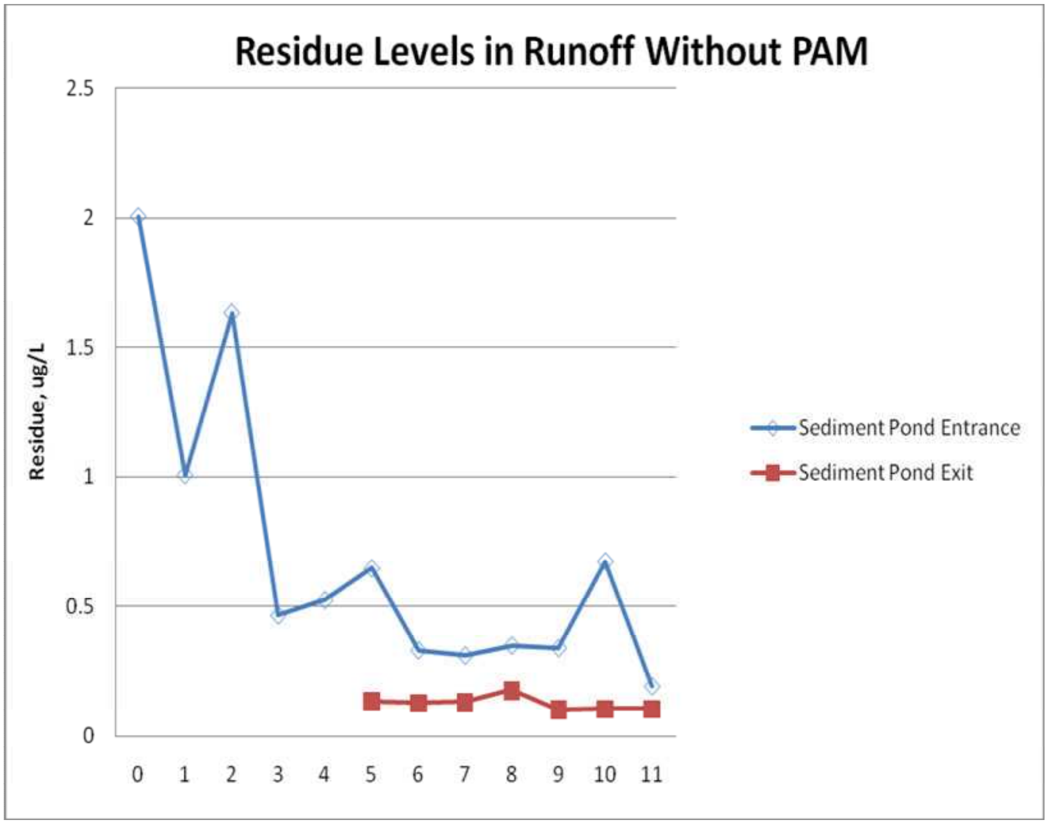


Figure 13. Pyrethroid Residues in Runoff Samples Following Treatment with PAM