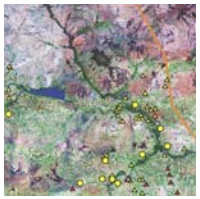

Refined Application of the SWAT Model for Endangered Species Effects Determination

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STONE ENVIRONMENTAL INC

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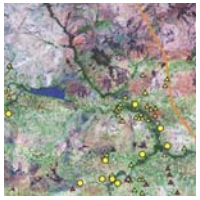
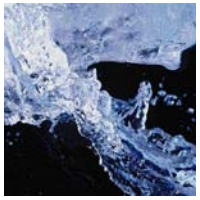


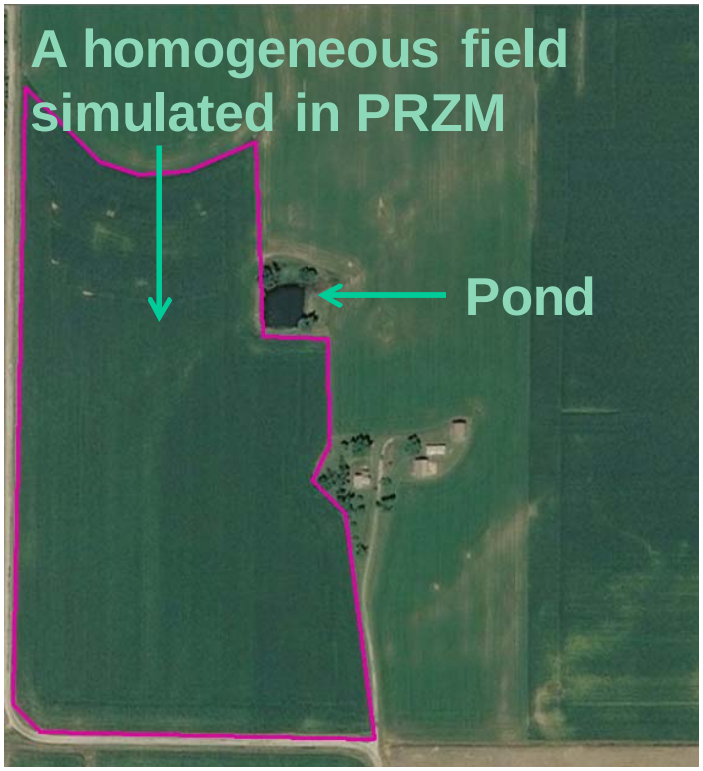


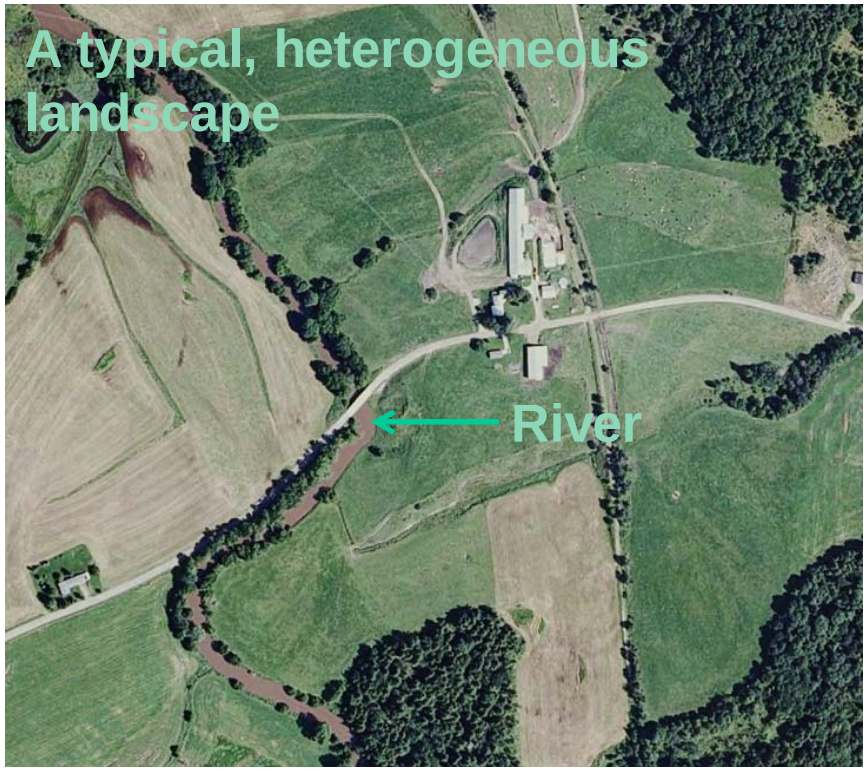
Background: Project Objectives and Approach

- Predict aquatic estimated environmental concentrations (EECs) of a commonly used insecticide in a highly vulnerable California Red-Legged Frog (CRLF) habitat.
- Use a model capable of predicting EECs in both flowing and non-flowing water bodies.
- Incorporate historical pesticide use data to probabilistically represent actual pesticide use patterns.
- Account for potential exposure from both runoff and spray drift sources.

Background: Motivation for Approach

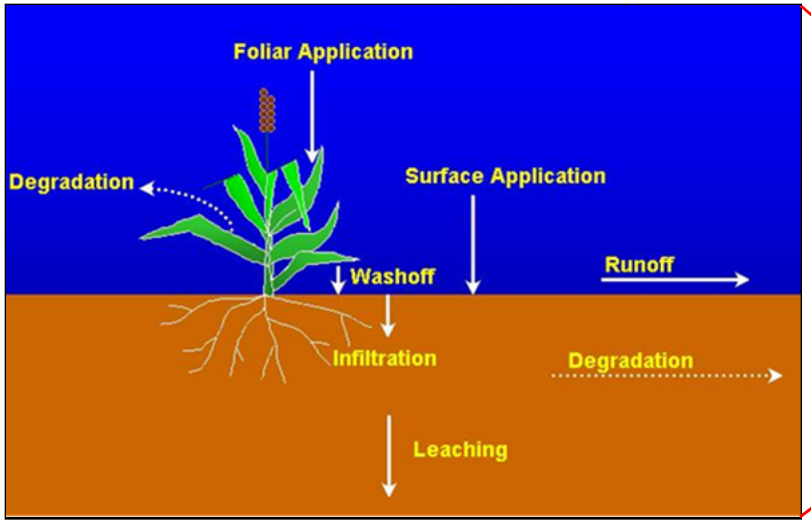
- PRZM/EXAMS standard scenarios are designed to simulate pesticide EECs in static water bodies (ponds) draining a homogeneous field.
- Many aquatic habitats of interest are flowing water bodies (rivers, streams, ditches) draining a heterogeneous landscape

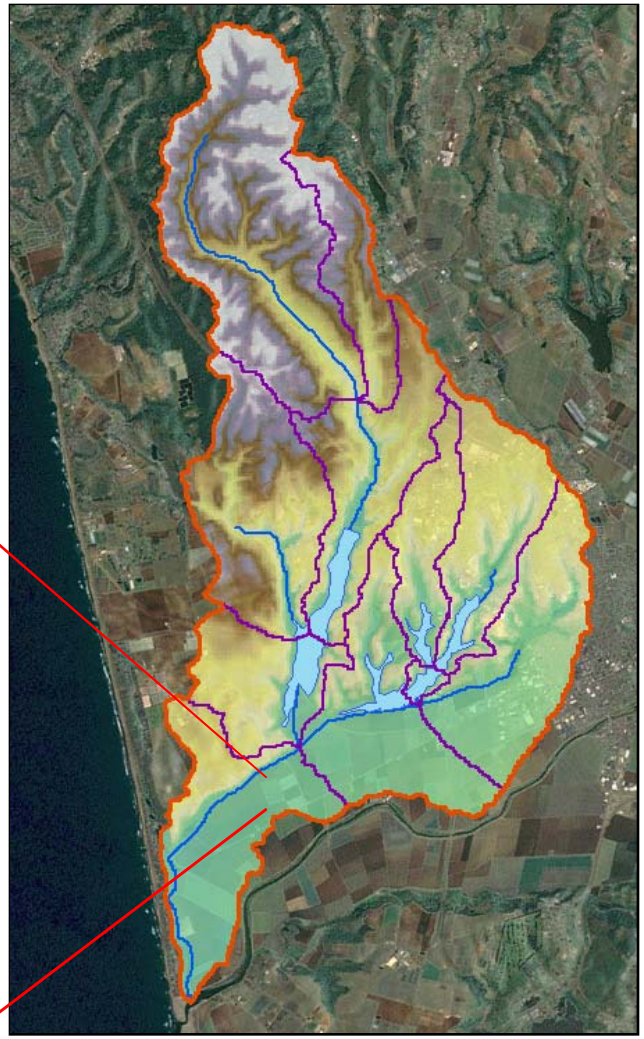




Background: Watershed Scale Modeling with SWAT

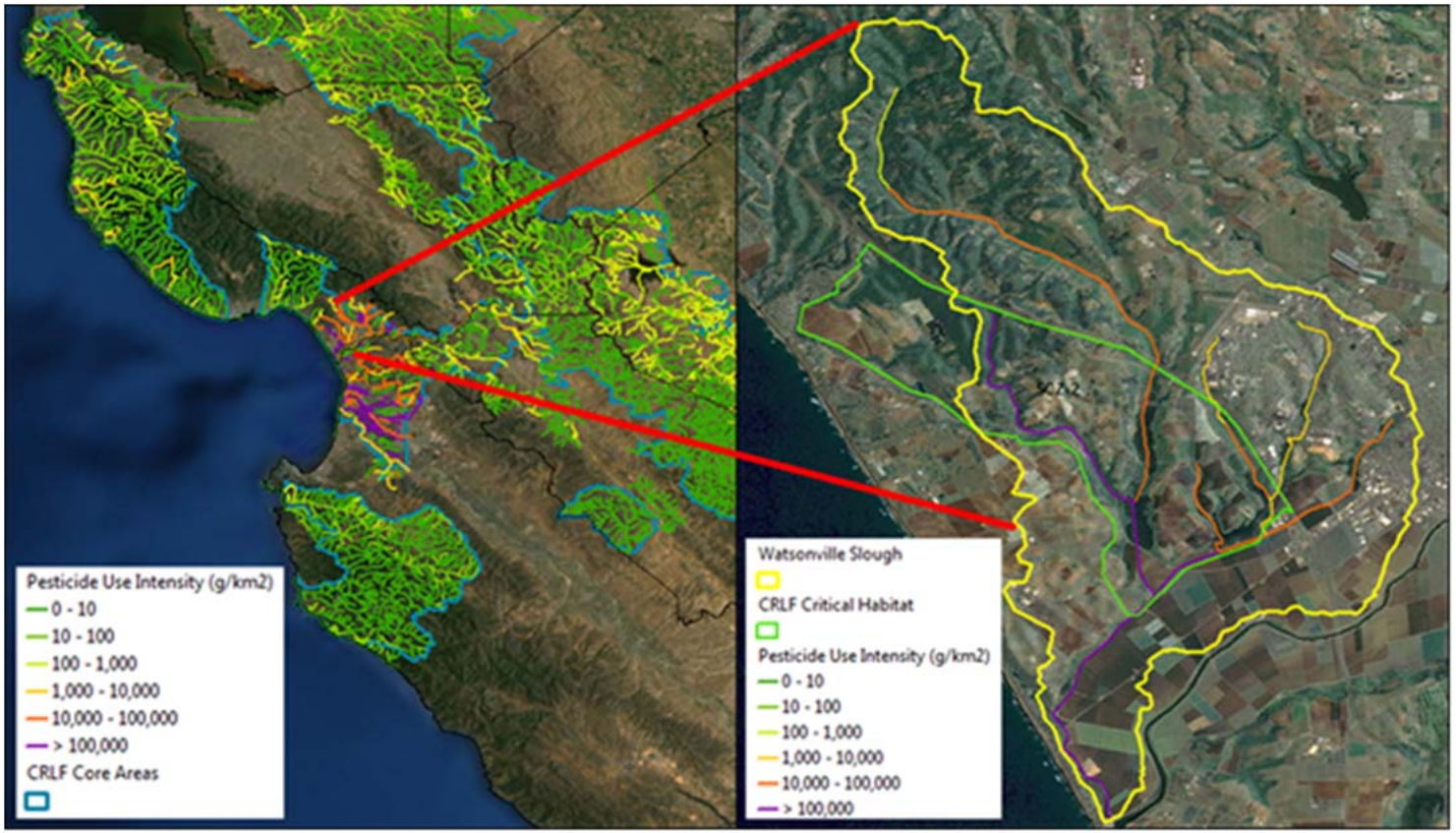
- Physically based, continuous simulation, management focused
- Land Pesticide Processes
  - Application, degradation, washoff
  - Runoff, interflow, leaching
- Water Body Pesticide Processes
  - Resuspension\settling
  - Degradation
  - Volatilization
  - Routing





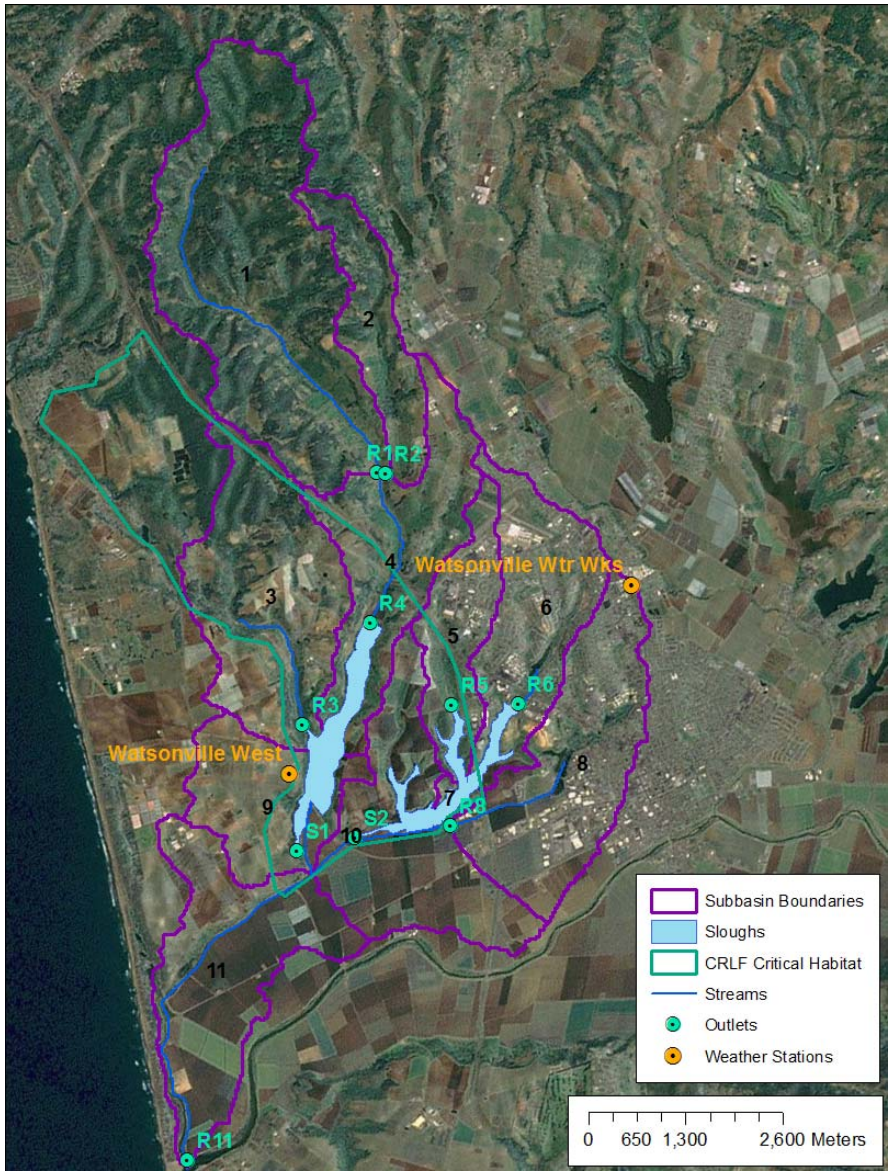
Background: Vulnerable Watershed Identification

- Upstream pesticide use intensity was assessed for all flowing water bodies (NHDPlus) within the CRLF core areas.
- The Watsonville Slough (WVS), a watershed containing streams representing above the 99th percentile upstream use intensity, was selected.



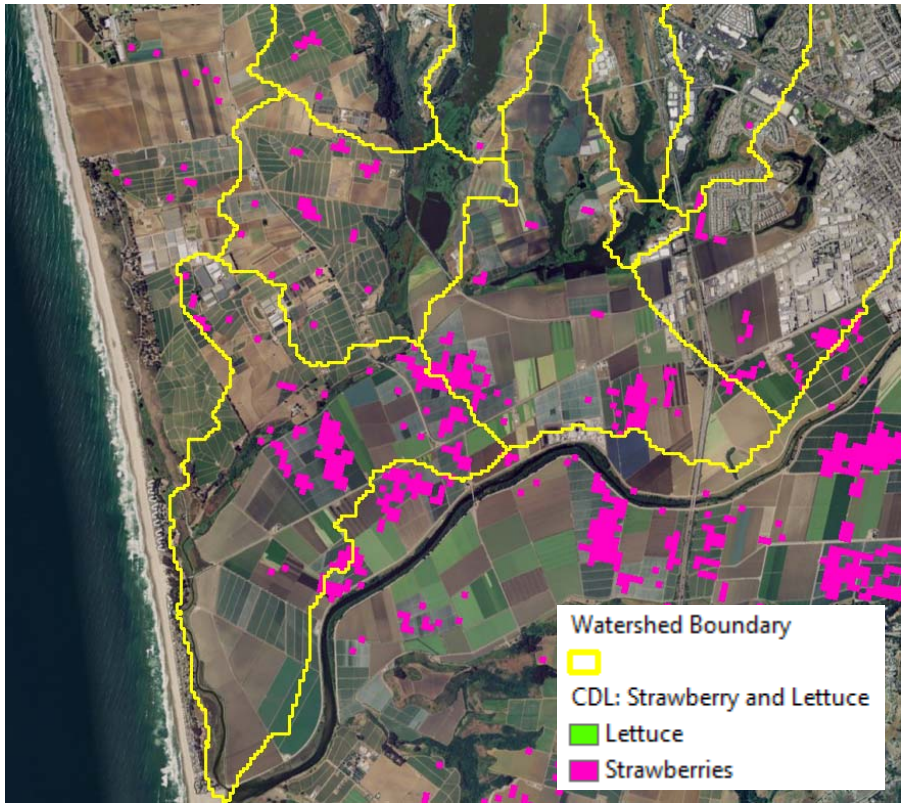
Input Datasets: Subbasins and Weather

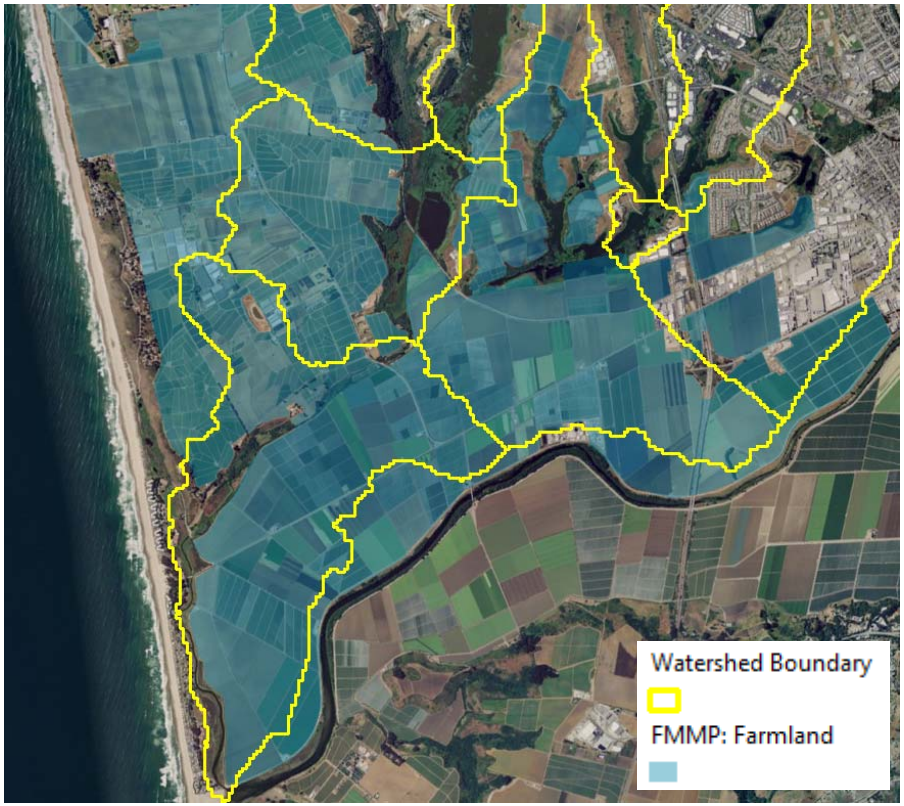
- The 20.3 mi^2 WVS watershed was delineated into 11 subbasins, including 2 major sloughs.
- Subbasins included intermittent and perennial streams, agricultural ditches, and the semi-stagnant sloughs.
- Two weather stations located within the watershed were used to represent the climate for a 31-year period from 1980 – 2010.



Input Datasets: Land Use Development

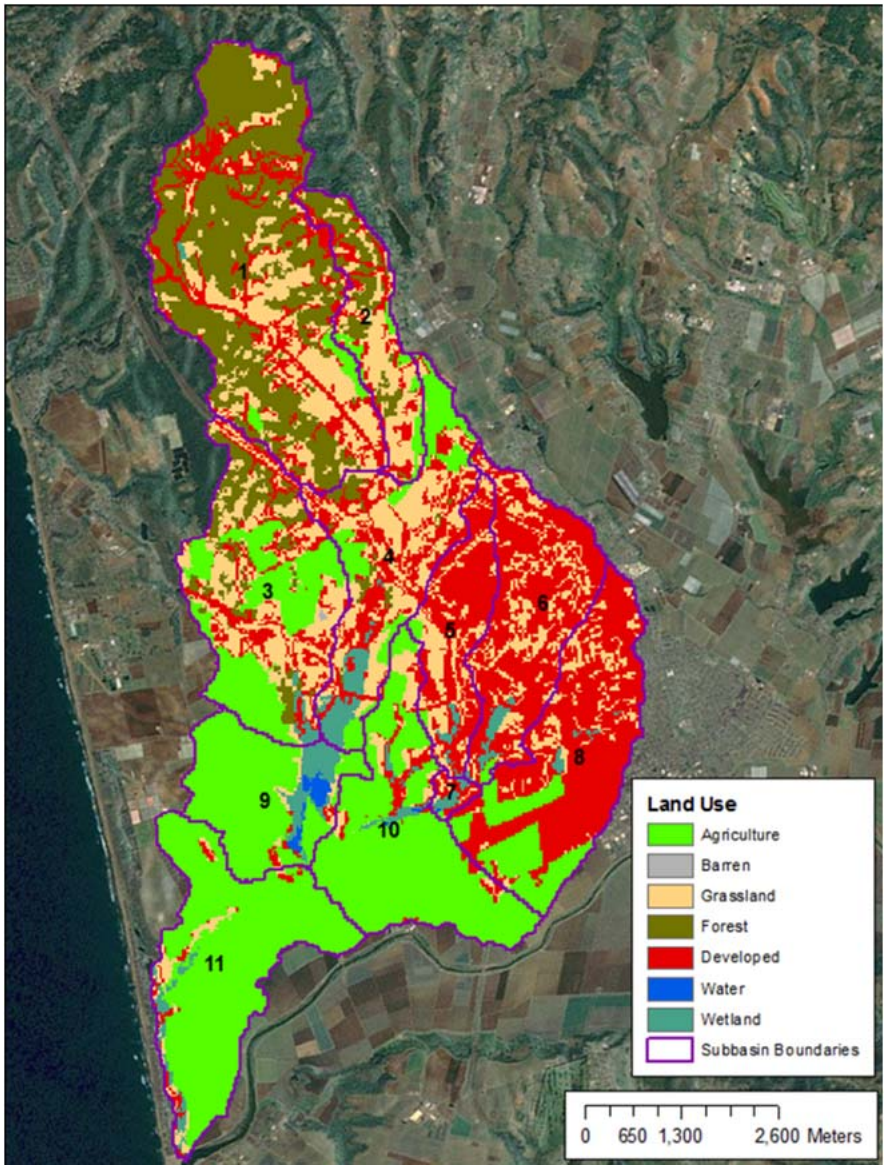
- The Cropland Data Layer (CDL) did not appropriately represent strawberry and lettuce, the major pesticide use crops in this watershed.
- The PUR and the CA Farmland Mapping and Monitoring Program (FMMP) datasets were used to represent agricultural land use.





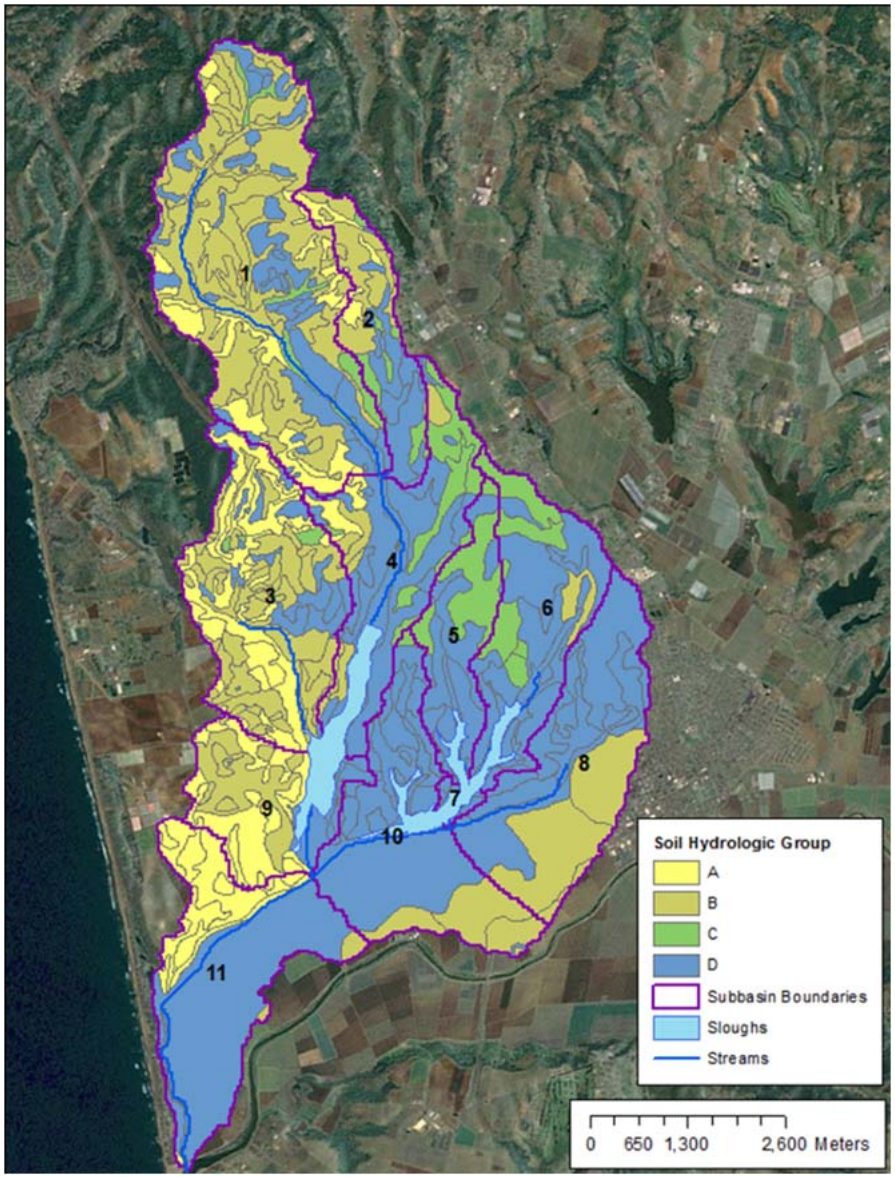
Input Datasets: Composite Land Use

- The FMMP agricultural land was merged with the 2006 National Land Cover Dataset (NLCD).
- 2007 Ag Census and the PUR database were used to characterize the crop types.
- Land use in WVS
  - Agriculture: 30%
  - Developed: 30%
  - Forest: 15%
  - Grassland: 20%
  - Other: 5%.



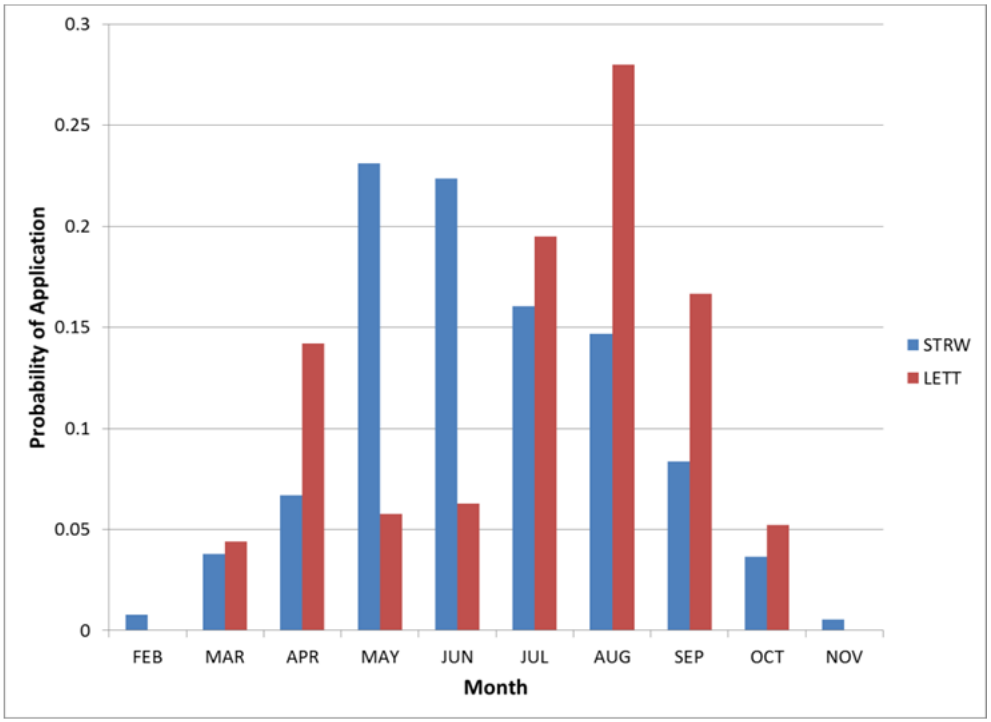
Input Datasets: Soils

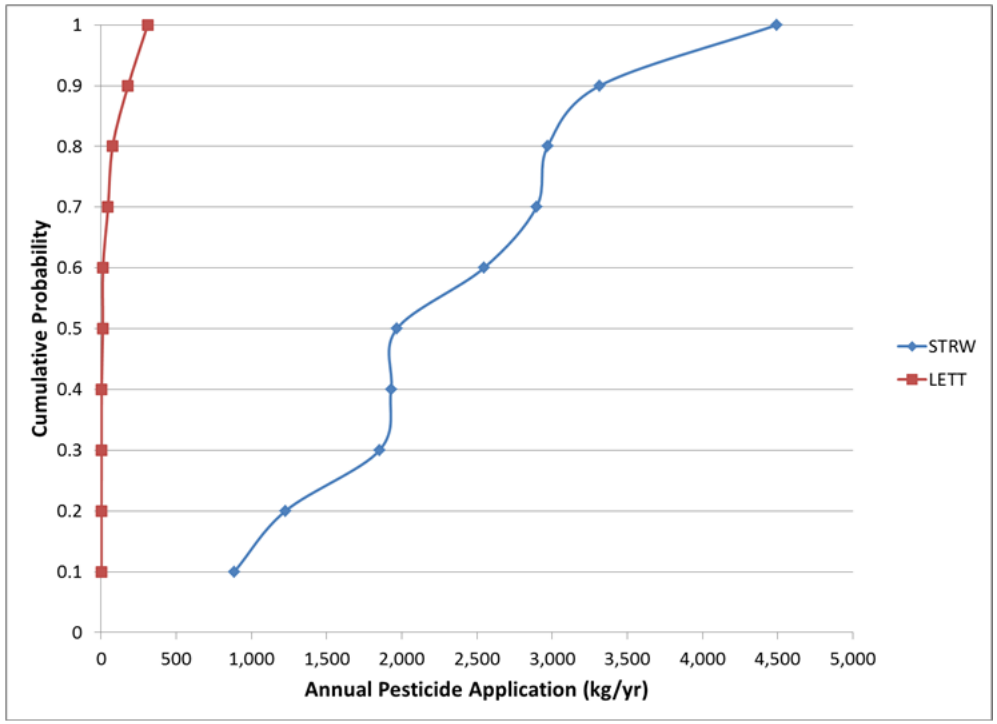
- The soil characteristics across the watershed were derived from the NRCS SSURGO database.
- A variety of runoff potential soils are found within the watershed, from lowest potential (hydro group A) to highest potential (hydro group D).
- The highest runoff potential soils (hydro group D) are most common.



Input Datasets: Pesticide Applications

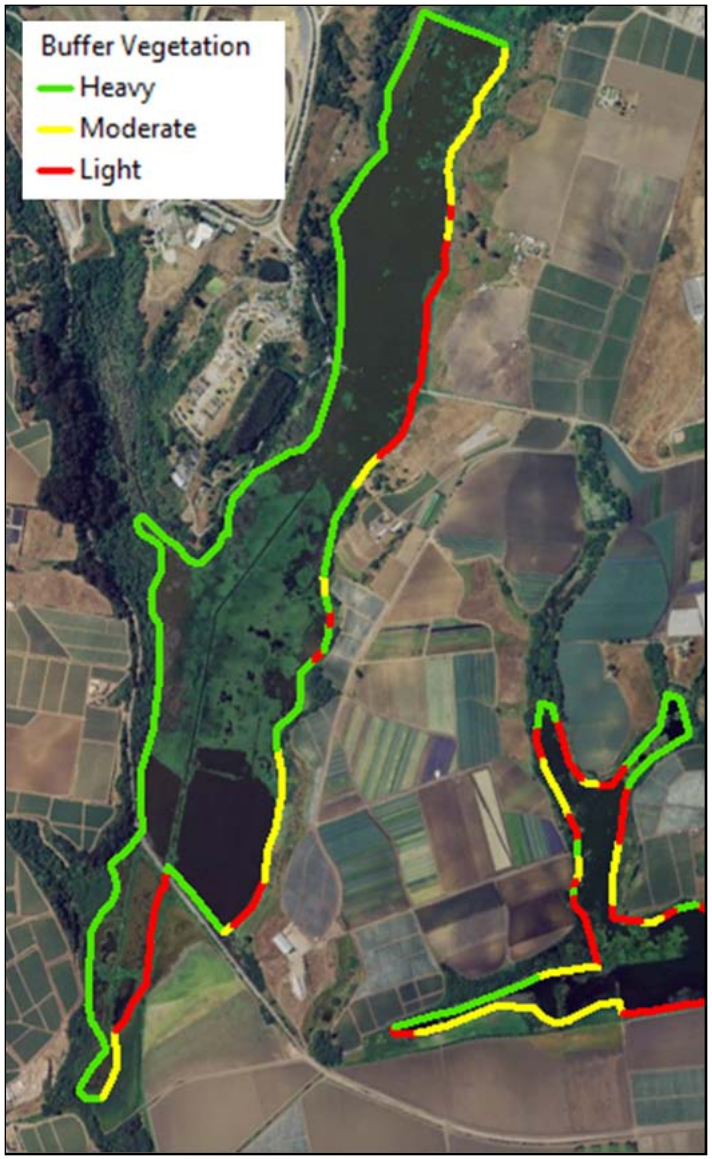
- Ten years of the CA PUR (2000 – 2009) were evaluated to quantify pesticide application timing and amount within the watershed.
- The monthly total applied provided application probabilities by month.
- The yearly total applied provided a discrete probability distribution of total annual pesticide use.





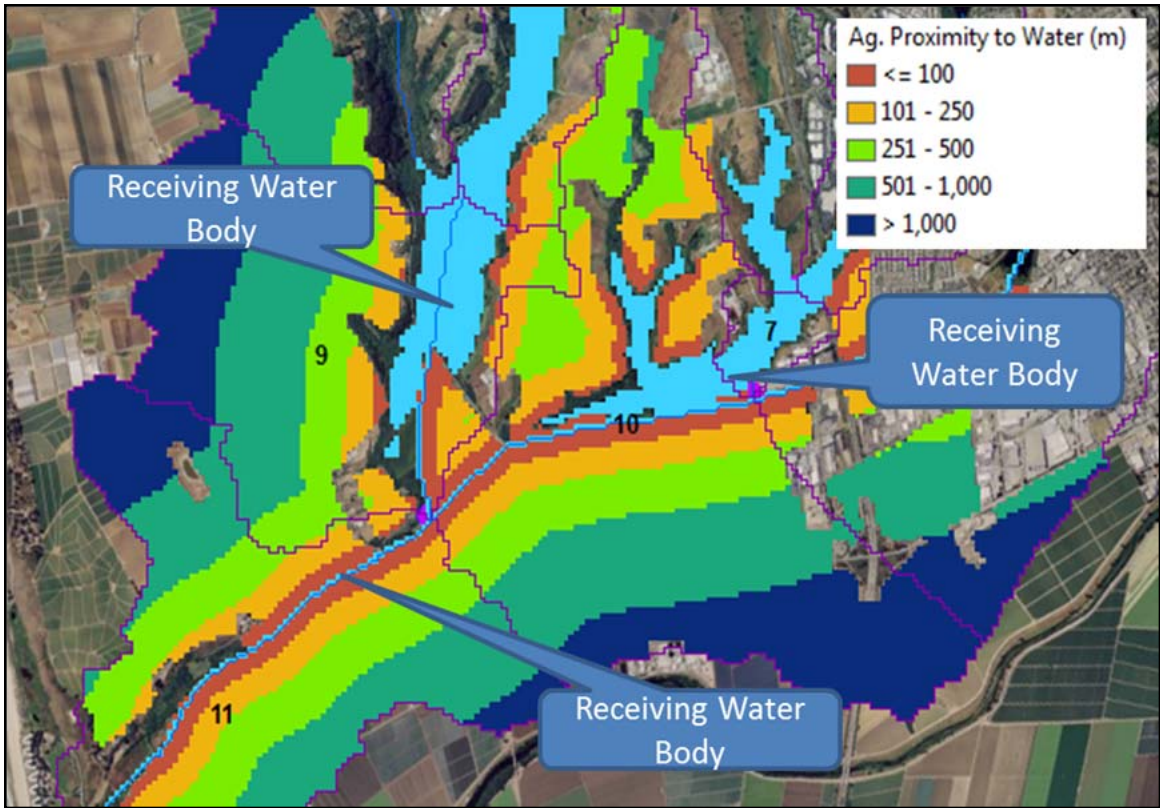
SWAT Modifications: Simulation of Spray Drift

- SWAT was modified to account for pesticide spray drift. Assumptions:
  - All application areas within a subbasin impact the same water body.
  - Ground applications beyond 200 m from a water body don't contribute drift.
  - Wind direction is variable, so applications are not always upwind.
  - Vegetation between an application and water body can reduce drift inputs.
  - Deposition is a function of proximity using Intrinsik ground spray drift curve.



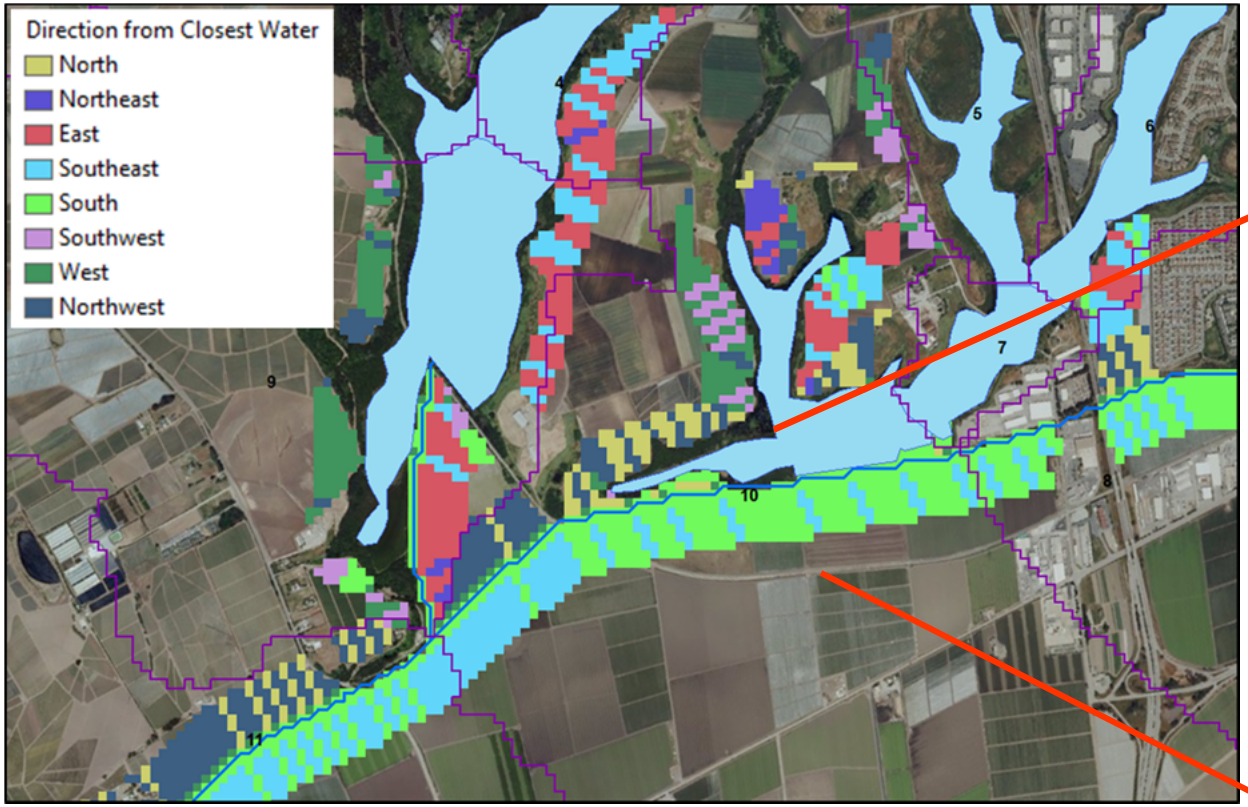
SWAT Modifications: Spray Drift Inputs, Proximity

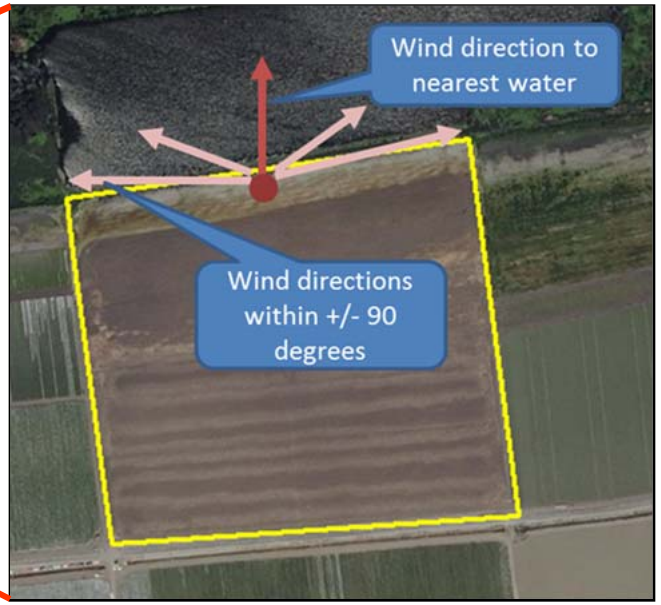
- The proximity of SWAT HRUs (fields) to the nearest receiving water body was determined.
- The area of strawberry/lettuce within 200 m of a receiving water had the potential to contribute spray draft as a direct input.



SWAT Modifications: Spray Drift Inputs, Orientation

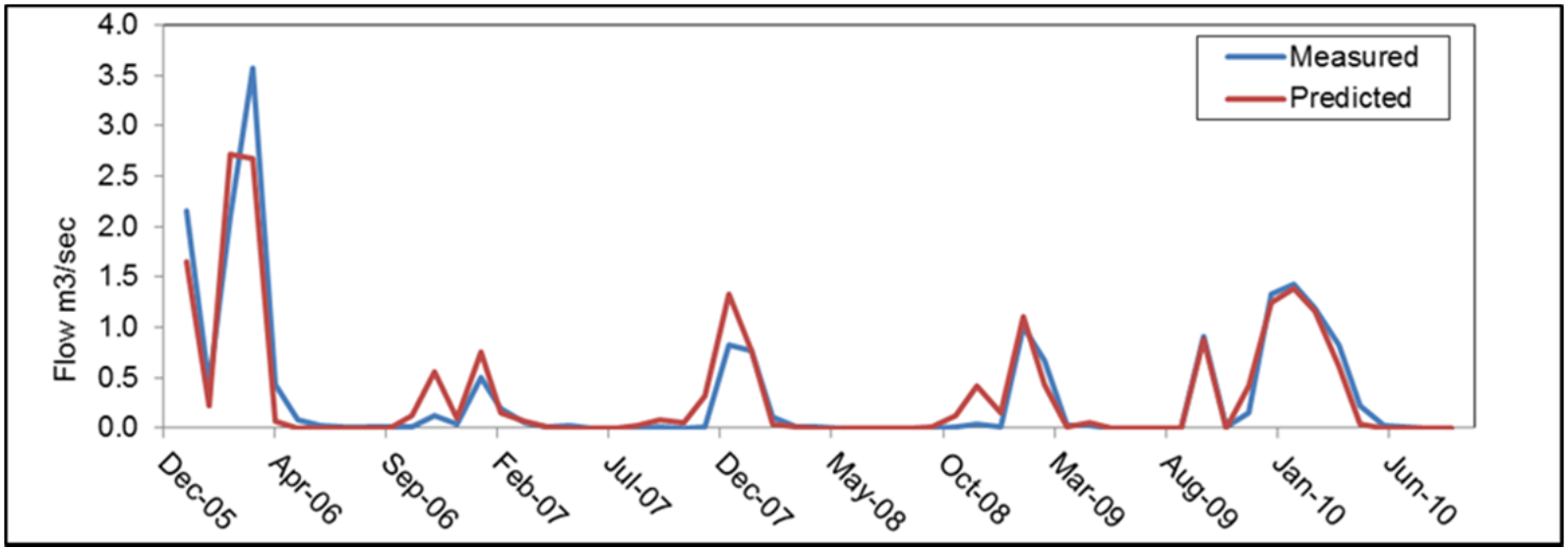
- The orientation (direction) of fields to the nearest water was determined.
- A wind direction of within +/- 90 degrees to the water body was assumed to contribute drift (conservative).





Model Application and Results: Flow Calibration

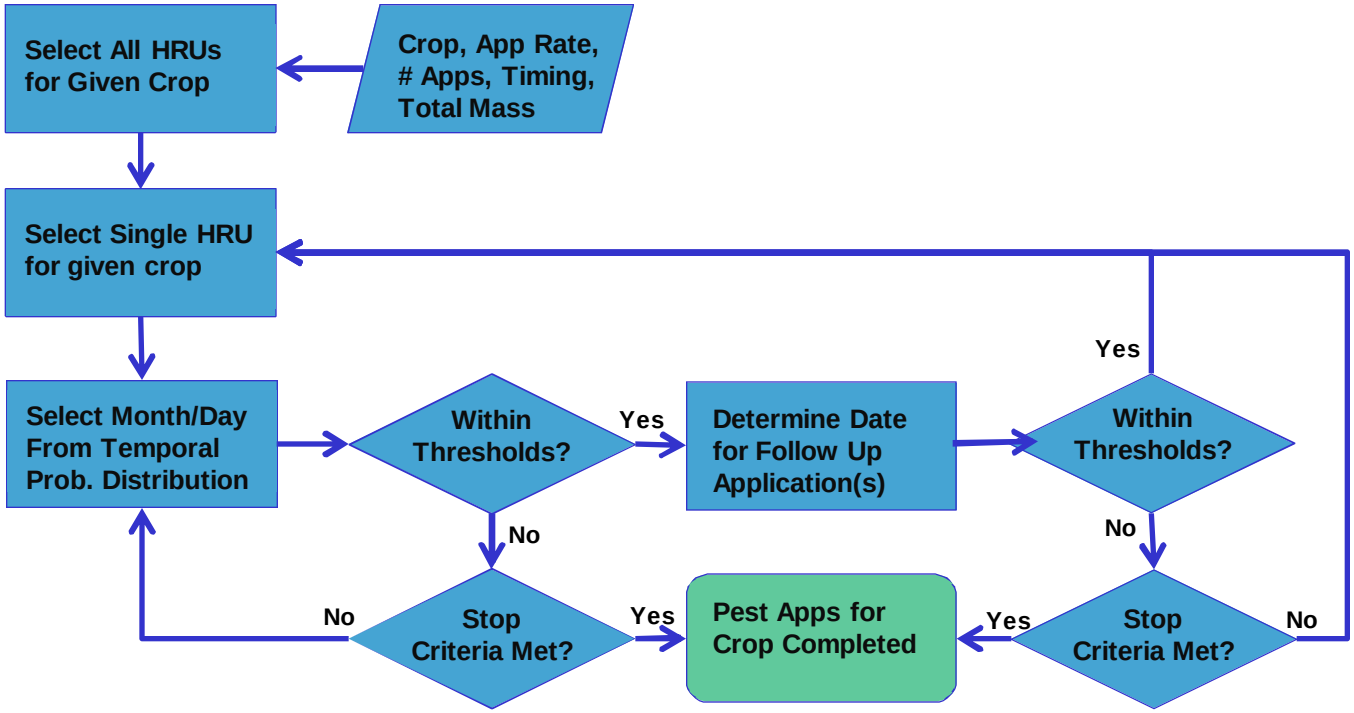
- Streamflow and pesticide concentration data were not available for the WVS.
- Streamflow data were available for an adjacent watershed (Corralitos Creek), where the hydrology was calibrated.
- Several key hydrologic parameter adjustments were transferred from the Corralitos watershed to the WVS.



Monthly Flow Calibration: NSE = 0.90; %Bias = -1.7%

Model Application and Results: Pesticide Application Simulation

- All applications are at maximum label rate for given crop.
- After a month is selected, the probability of an application on any given day in the month follows a uniform distribution.
- Multiple applications on same HRU (field) are made at the minimum interval, as allowed by total watershed mass and timing constraints.

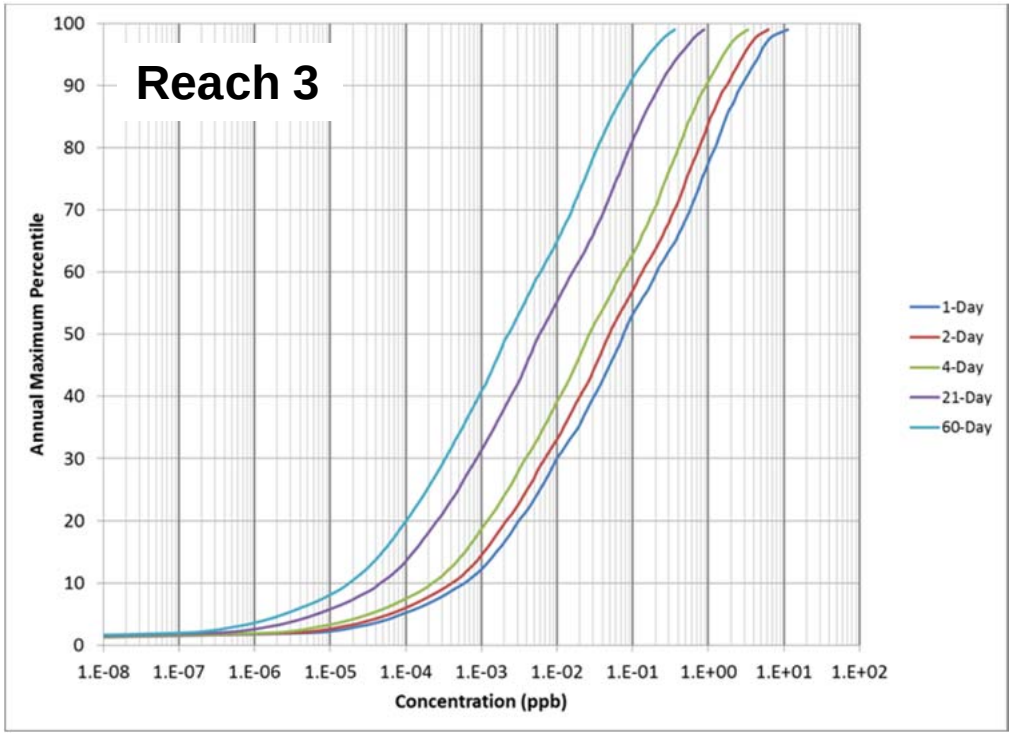


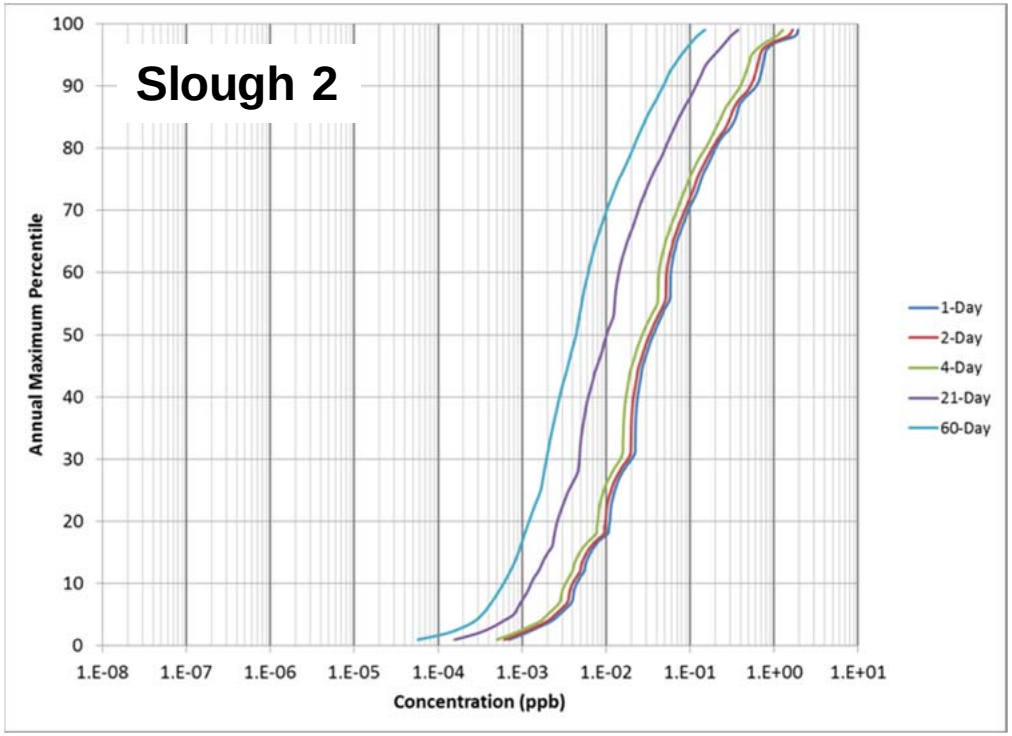
Model Application and Results: Monte Carlo Simulations

- A single SWAT simulation for 30 years will result in 30 annual peak EECs (varying due to weather conditions).
- Variable inputs to WVS SWAT model in include:
  - Amount of pesticide applied in a given year (from PUR)
  - Pesticide application timing (from PUR)
  - Which fields receive pesticide applications (randomized)
  - Whether spray drift will impact a water body (based on wind statistics)
  - Hydrologic characteristics of the sloughs
- SWAT was run 500 times, altering these inputs for each simulation (a “Monte Carlo” simulation), resulting in 15,000 annual peak EECs in each water body.

Model Application and Results: SWAT Simulation Results

- SWAT Monte Carlo simulations provided a distribution of EECs for each water body for 1-day to 60-day exposure durations.
- EECs for Reach 3 (a tributary to the slough) show greater variability than for the slough.





Model Application and Results: PRZM/EXAMS Comparison with SWAT

- The EECs predicted from PRZM/EXAMS based on local weather and refined e-fate characteristics were compared with EECs predicted by the SWAT model for the WVS water bodies.
- This comparison shows that PRZM/EXAMS EECs were between 12 and 50 times higher than the SWAT EECs for the most vulnerable water body in the WVS (water body with the maximum EEC).

90th %-ile EEC Duration	SWAT (10 WVS Water Bodies)			PRZM/EXAMS EEC for Strawberry	PRZM/SWAT Ratio
	Minimum	Median	Maximum		
Peak	0.03	0.60	2.92	36.32	12
21-day	0.00	0.07	0.25	12.18	50

Summary and Conclusions

- A watershed modeling approach using SWAT was applied to predict pesticide EECs throughout the Watsonville Slough, a highly vulnerable watershed overlapping the CRLF core and critical habitat areas.
- SWAT was modified to allow chemical contributions from spray drift to directly impact water bodies within the watershed.
- The applications of pesticide within the watershed were parameterized based on 10 years of historical use data from the CA PUR database.
- Distributions of predicted EECs throughout the watershed were based on a Monte Carlo simulation that varied pesticide application, wind, and hydrologic assumptions.
- Plans for future refinement of this approach include a more spatially explicit handling of spray drift inputs through a more discretized representation of agricultural fields.

THANK YOU