Monitoring Urban Waterways: DPR's Surface Water Protection Program

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DPR Brown Bag Lunch www.cdpr.ca.gov/docs/dept/brownbag/
CalEPA Sierra Hearing Room
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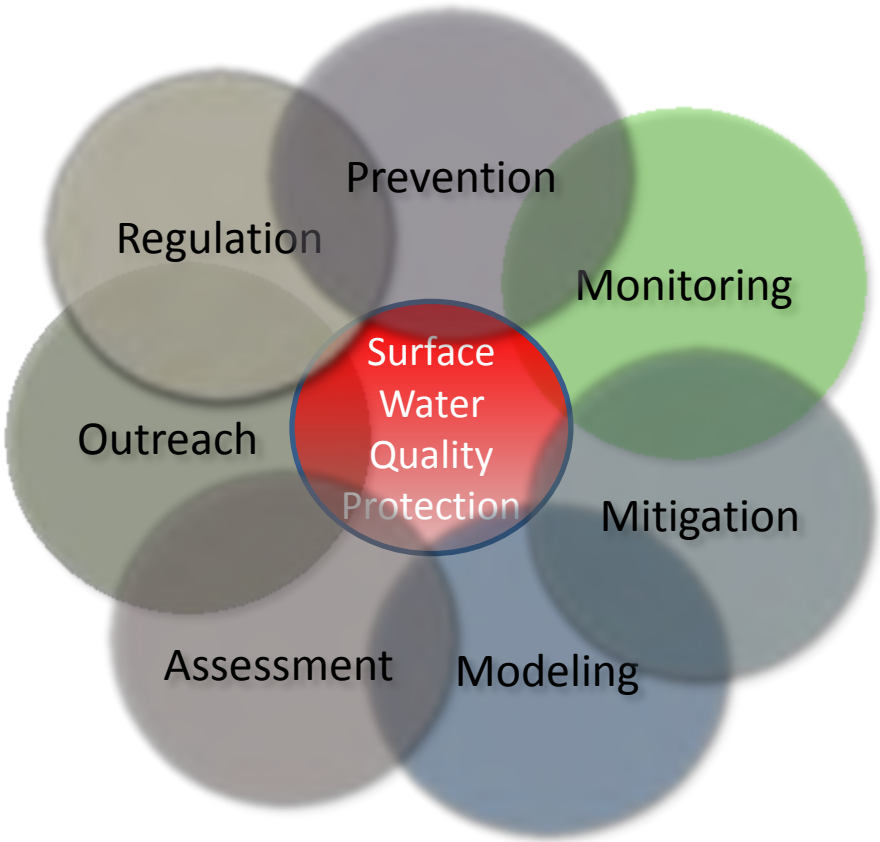
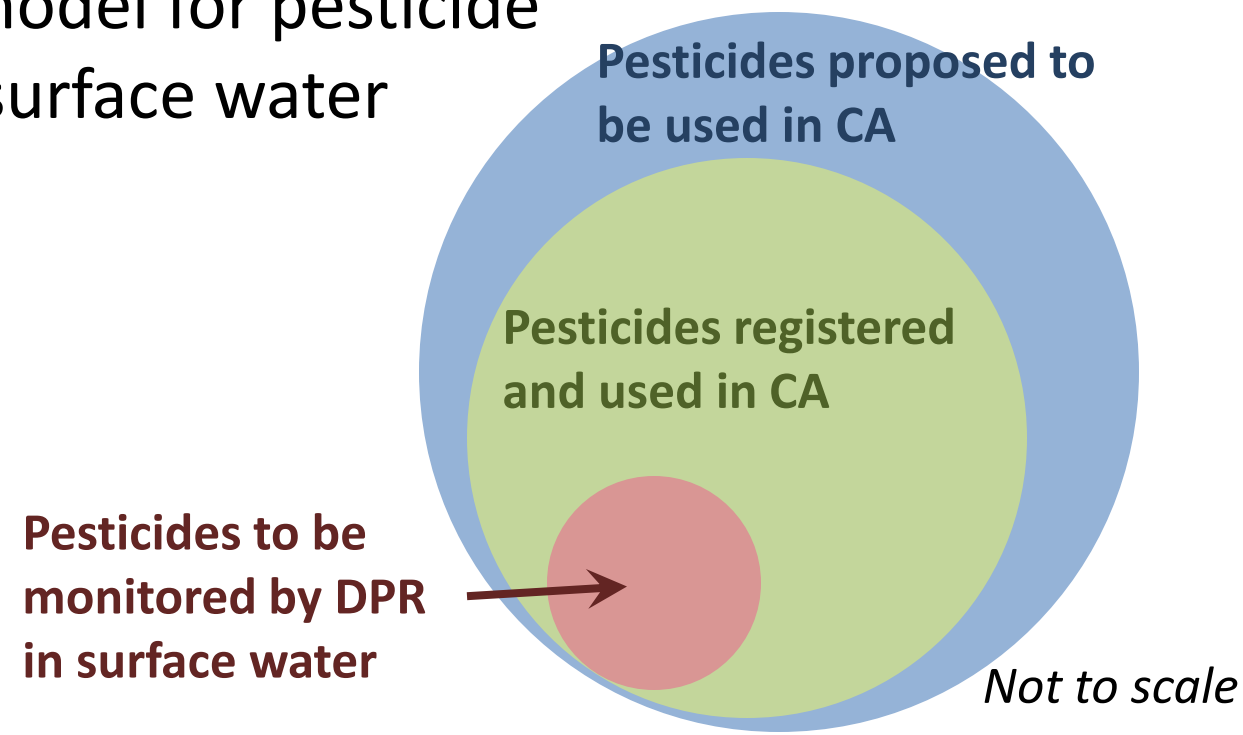
DPR's Surface Water Protection Program (SWPP)



Modeling as Prevention

- Pesticide registration evaluation model for surface water protection

- Prioritization model for pesticide monitoring in surface water



Pesticide Registration Evaluation

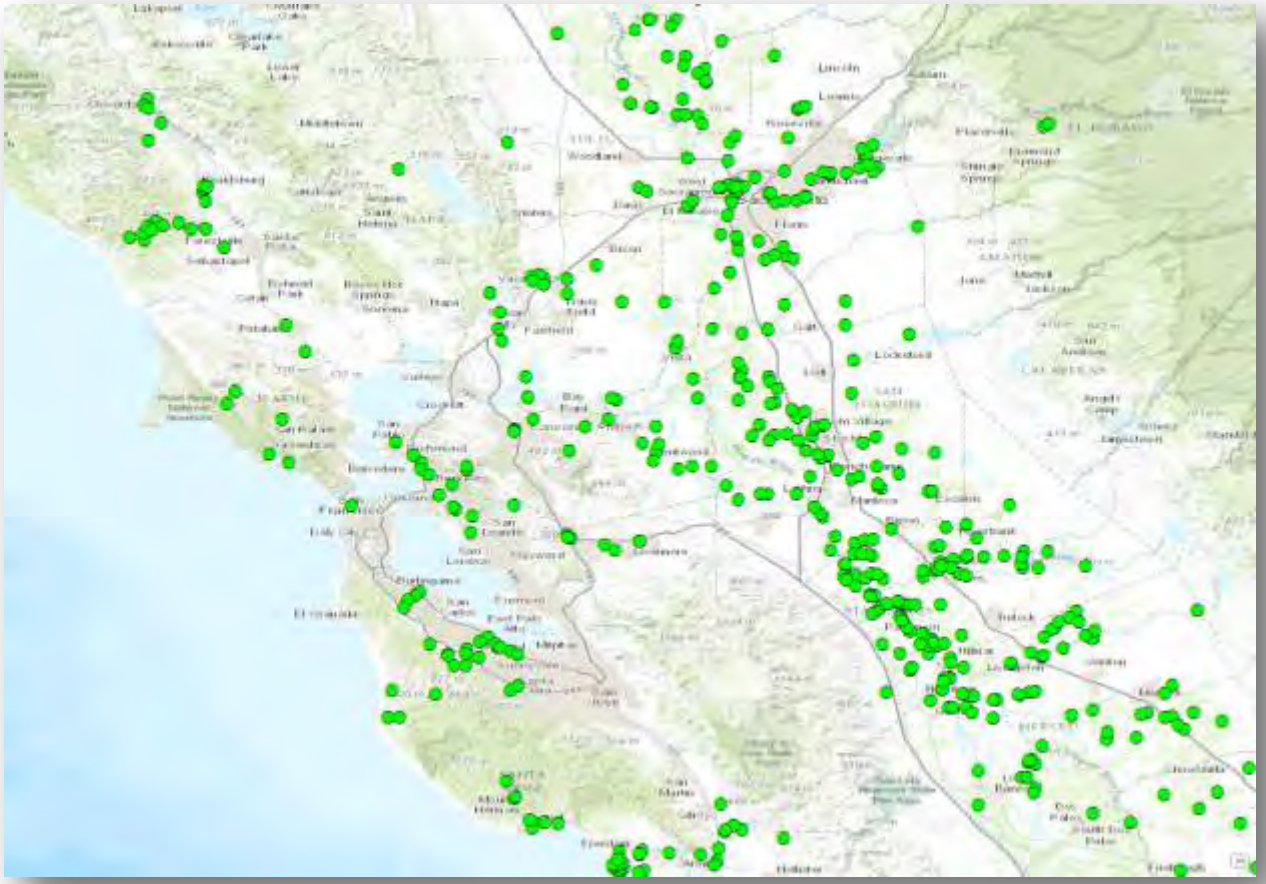
- DPR's SWPP has been developing a more consistent, transparent, and efficient methodology

- Early version was released in 2012. It continues to evolve to better fit California conditions

- Registration recommendations
  - Not to support registration
  - To support registration with no condition
  - To support conditional registration (request analytical methods, and place in a watchlist for monitoring)

Pesticide monitoring in SW

- Where, when, and what to sample?



Historical and active monitoring sites (by DPR and other agencies) reporting pesticide concentrations (DPR Surface Water Database)

Pesticide monitoring in SW

- Where, when, and what to sample?

Screen Group*	March	April-September	May, July, September	October
	Imperial PVOD**	Monterey	Santa Barbara San Luis Obispo	Imperial
AZ	X			
2,4-D	X			
DA				X
DN/OX	X	X	X	X
DZ		X		
IMD/BEN		X	X	X
ME	X	X		X
OP	X	X	X	X
Oxydemeton -methyl		Pending		
Paraquat dichloride		Pending		
PY		X		X
STR			X	

Monitoring study protocol, DPR study 297 (Deng, 2015) as an example
http://cdpr.ca.gov/docs/emon/pubs/protocol.htm

Pesticide monitoring in SW

- Where, when, and what to sample?

- Prioritization workgroup
  - "*Establish computer programs to integrate and facilitate the automation of updating the agricultural and urban monitoring priority lists*" (workgroup charter, 2012)

- Output: a prioritization model which generates a priority list of pesticides for surface water monitoring

Project homepage

http://www.cdpr.ca.gov/docs/emon/surfwtr/monitoring_methods.htm

SWMP (Surface Water Monitoring Prioritization Model)

SWMP model is developed to prioritize pesticides for surface water monitoring in agricultural and urban areas of California. For the generation of monitoring priority lists of pesticide ingredients and their degradates, the model incorporates pesticide use and toxicity data, as well as chemical properties, monitoring results, and application information. Advanced options are also provided in the model for monitoring prioritization at various spatial and temporal scales, with user-defined months, years, counties, and watersheds.

- SWMP Quick Start Guide, PDF (124 kb), Video
- Executable and supporting database (.zip compressed file), version 3.0 (8.9 mb)
- User's manual, PDF (1.2 mb)
- Technical Reports
  - Analysis Report, PDF (1.1 mb). Yuzhou Luo, Xin Deng, Robert Budd, Keith Starner, Michael Ensminger. 2013. May 28, 2013.
  - Analysis Memo, PDF (536 kb). Yuzhou Luo, Michael Ensminger, Robert Budd, Xin Deng, and April DaSilva, 2014. II: Refined Priority List.
  - Analysis Report, PDF (763 kb). Yuzhou Luo and Xin Deng, 2015. III: Watershed - Based Prioritization.

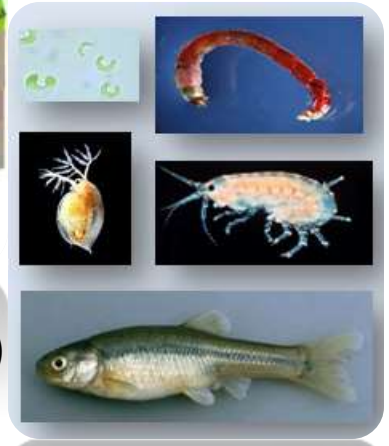
Conceptual Model

(from source to receptor)

Pesticide application

Off-site movement to water

Fate and transport within stream network (watershed)



Impacts on ecosystem

Required data:

Pesticide use data

Landscape characteristics

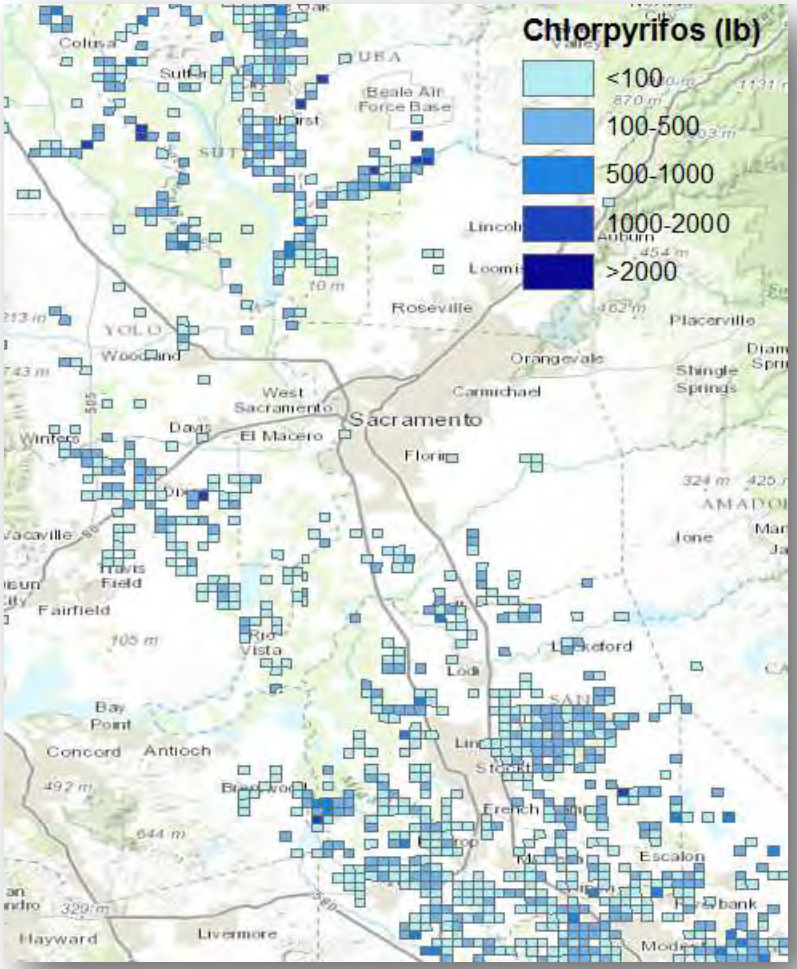
Hydrology data

Ecotoxicology data

Chemical properties

Input data

- DPR's Pesticide Use Reporting (PUR) database
  - Released annually, 1989-2013
  - Agricultural uses: daily data, for each section (1x1mi^2)
  - Non-agricultural uses: monthly data, for each county
  - http://www.cdpr.ca.gov/docs/pur/purmain.htm



Chlorpyrifos use data in 2013 (lb/section) →

Input data

- Pesticide Use Reporting (PUR), DPR
- National Hydrography Dataset (NHD), USGS (U.S. Geological Survey)
- Pesticide Property Database, IUPAC (International Union of Pure and Applied Chemistry)
- Aquatic Life Benchmarks, USEPA (U.S. Environmental Protection Agency)

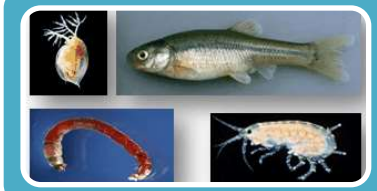
Modeling Processes

Prepare pesticide use data by watershed

- Agricultural uses: aggregation from section (1x1mi^2) to watershed
- Non-agricultural uses: upscaling from county to watershed

Classify pesticides for potential aquatic risks by use pattern, application method, runoff potential

Route pesticides through stream network for their "effective uses" for a given sampling location, by considering pesticide accumulation and dissipation



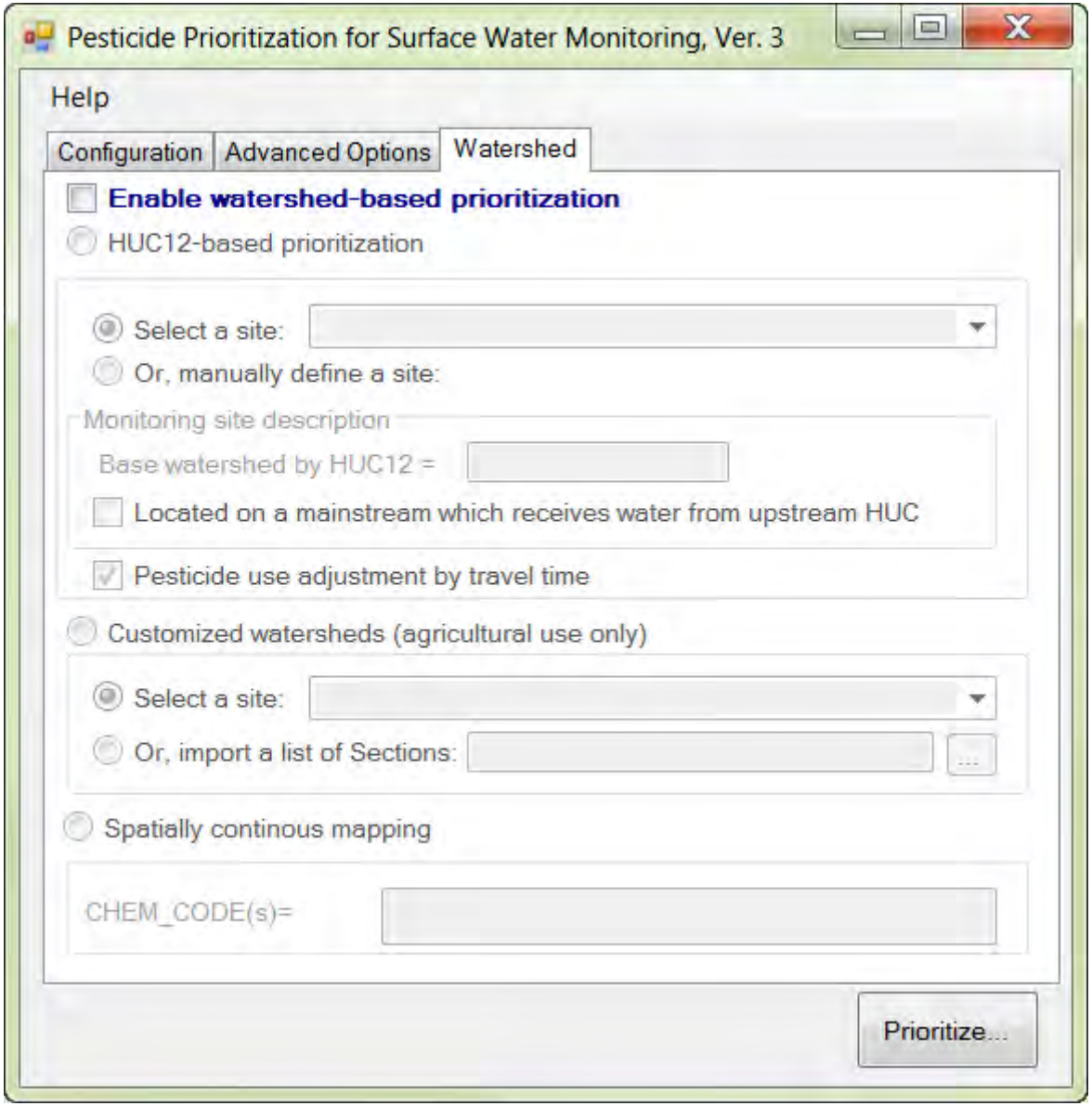
Rank pesticides by effective uses and toxicity data, and make recommendations for monitoring

Pesticide rankings

- [1] Priority scores
  - [**use score**] (1~5) and [**toxicity score**] (1~8)
  - [**final score**]= [toxicity score]*[use score]

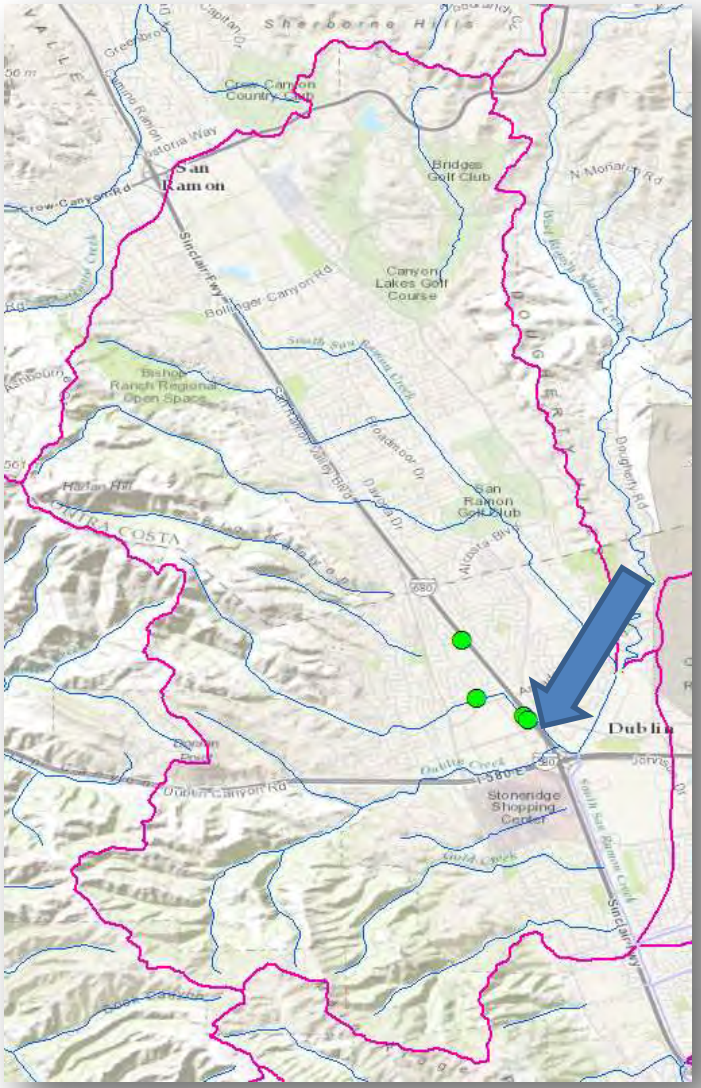
- [2] Indicators for pesticide fate and transport
  - Pesticide use patterns, application methods, volatility (soil, water), soil-runoff potential, aquatic persistence, bio-accumulation, bio-availability, …

Graphic User Interface



Model application, example 1

- Model settings
  - A DPR site in Alameda County
  - For urban receiving water
  - Annual PUR data 2011-2013
  - Acute aquatic benchmark for risk characterization



Results

Pesticide use (lb) and use score

Benchmark (ppb) and toxicity score

[final score]=[use score]*[toxicity score]

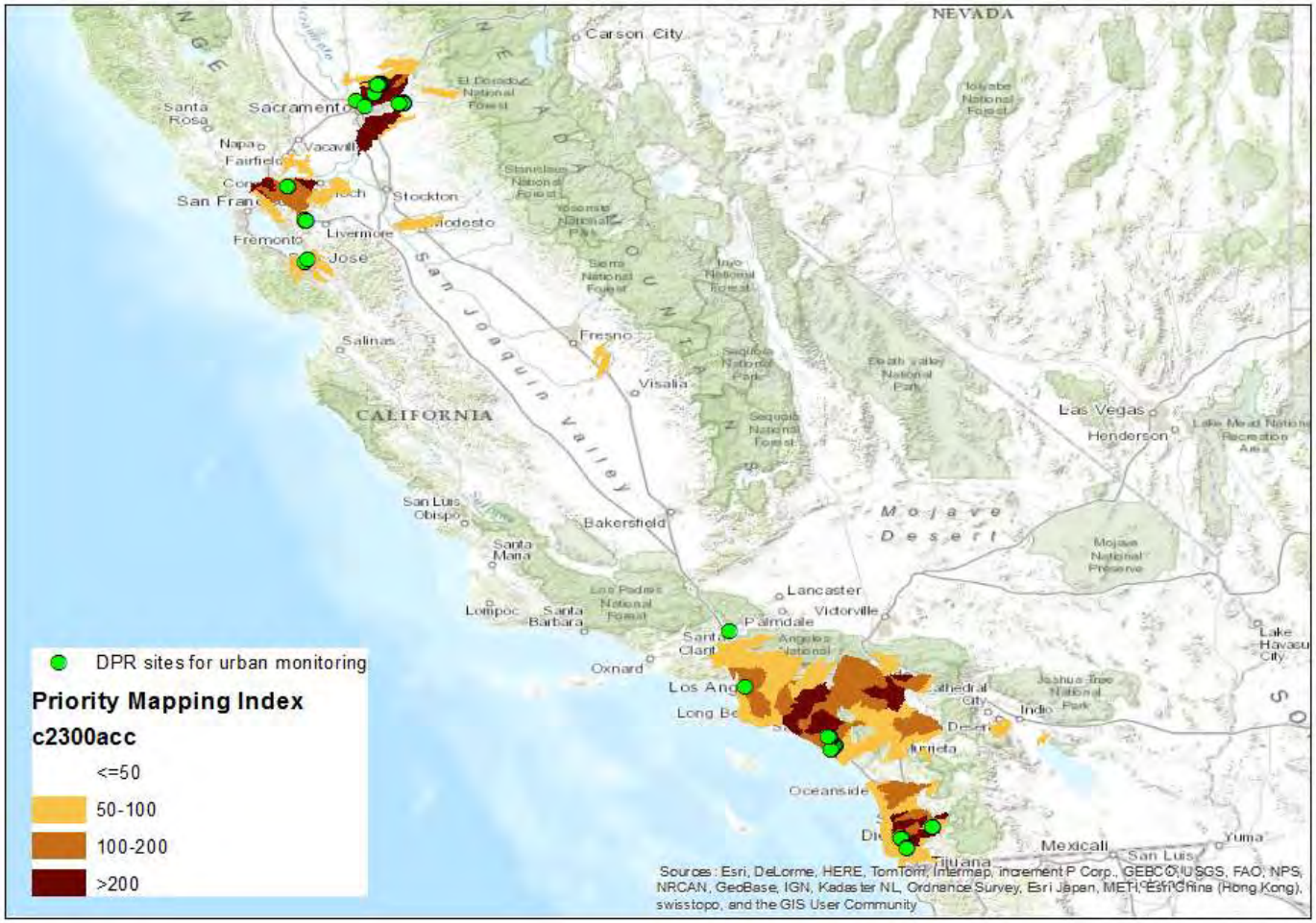
- Top-10 model-suggested pesticides for monitoring

CHEMNAME	use	usescore	benchmark	toxscore	finalscore
CYFLUTHRIN	112.8	5	0.0125	6	30
BIFENTHRIN	222.6	5	0.075	6	30
DELTAMETHRIN	53.8	4	0.055	6	24
FIPRONIL	70.6	4	0.11	5	20
DIURON	260.1	5	2.4	4	20
BROMACIL	208.2	5	6.8	4	20
PERMETHRIN	26.1	3	0.0106	6	18
PENDIMETHALIN	47.7	4	5.2	4	16
CYPERMETHRIN	13.5	3	0.195	5	15
LAMBDA-CYHALOTHRIN	9.6	2	0.0035	7	14

- All of the 10 pesticides have been included in the previous DPR monitoring (DPR Studies #249, #264)

Model application, example 2

- Spatially continuous mapping for *bifenthrin* (non-agricultural use)



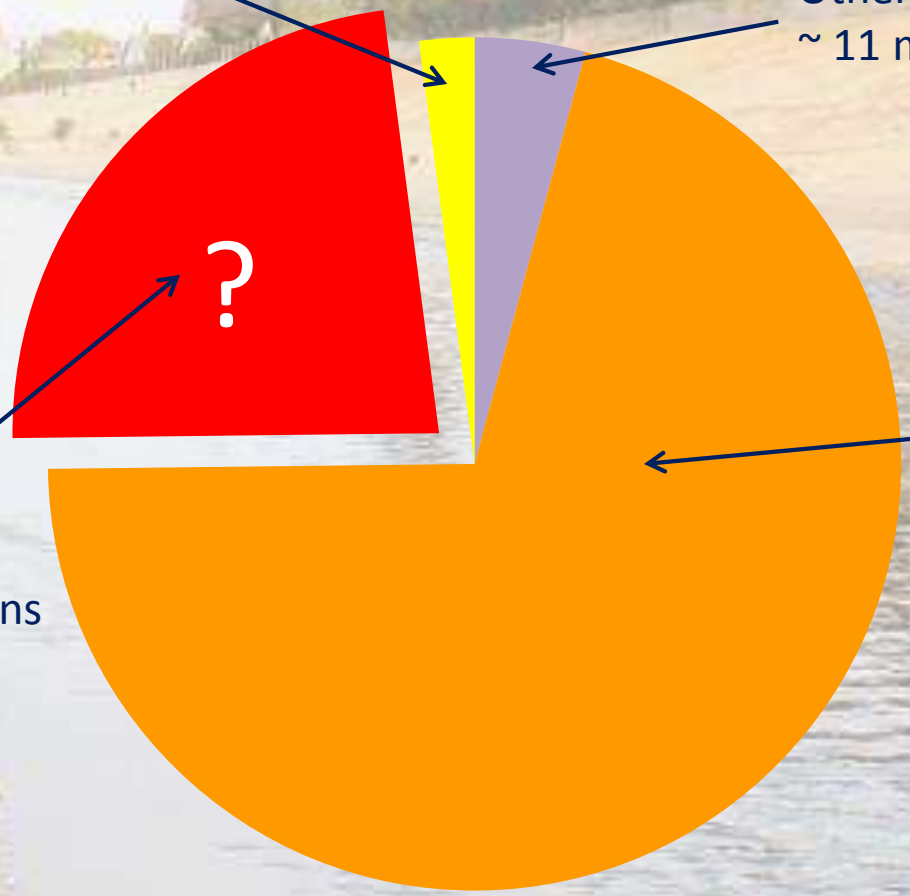
Urban Monitoring Program
The Essentials

Urban Monitoring Program

1) Why monitor urban runoff?
2) What should be monitored?
3) Where to monitor?
4) When to monitor?
5) How - what methods?
6) What does it all mean?

Urban Monitoring Program

1) Why monitor urban runoff? → High urban pesticide use



Professional Urban Applications
~5 million pounds (PUR)

Other*
~ 11 million pounds (PUR)

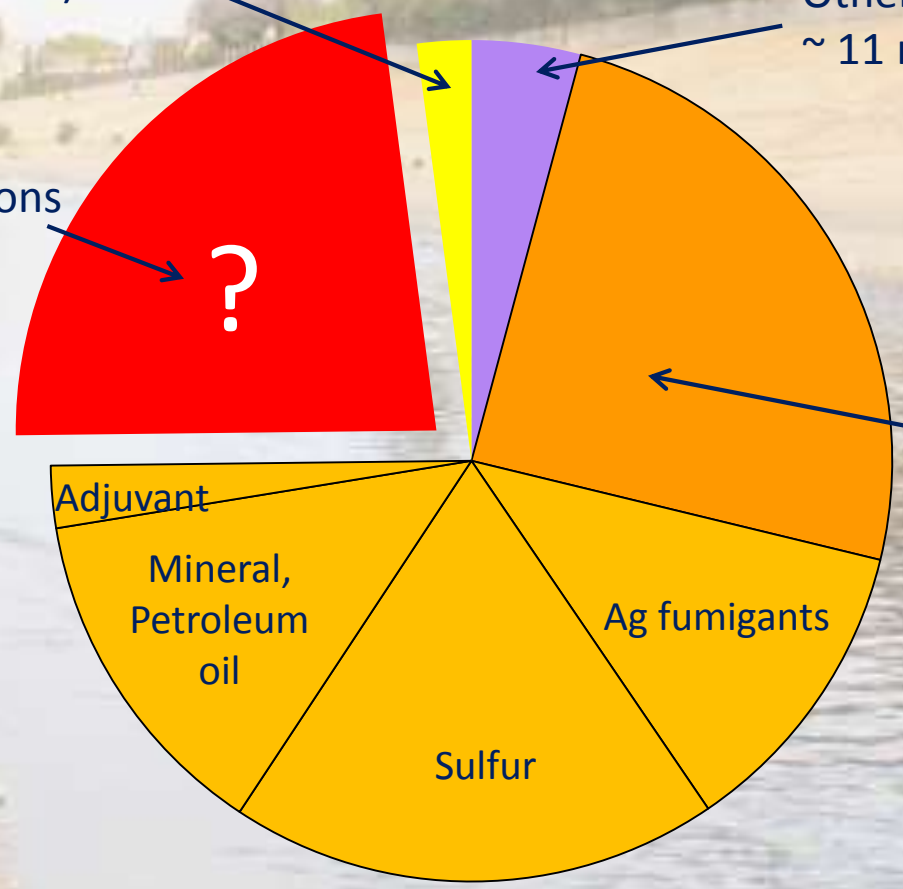
Agricultural Applications
~178 million pounds (PUR)

Unreported Homeowner Applications
(est. 25% of total;
58 million pounds)

*post-harvest fumigation, non-production agricultural

Urban Monitoring Program

1) Why monitor urban runoff? → High urban pesticide use



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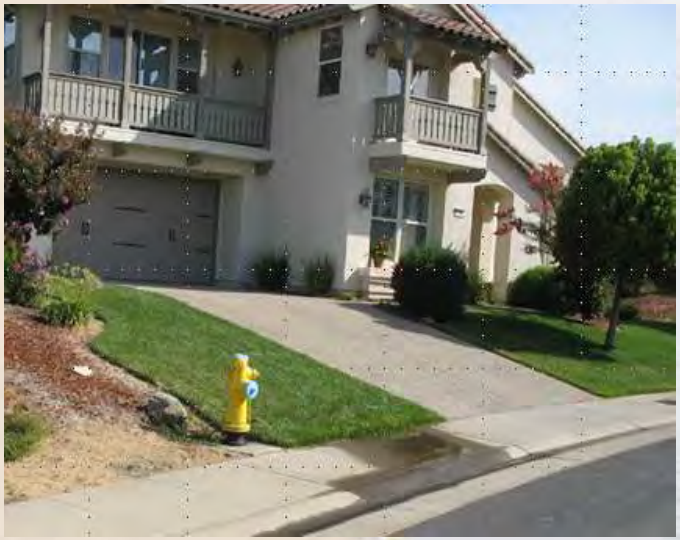
Urban Monitoring Program

1) Why monitor urban runoff? → High urban pesticide use

Continuous connectivity

Lot size

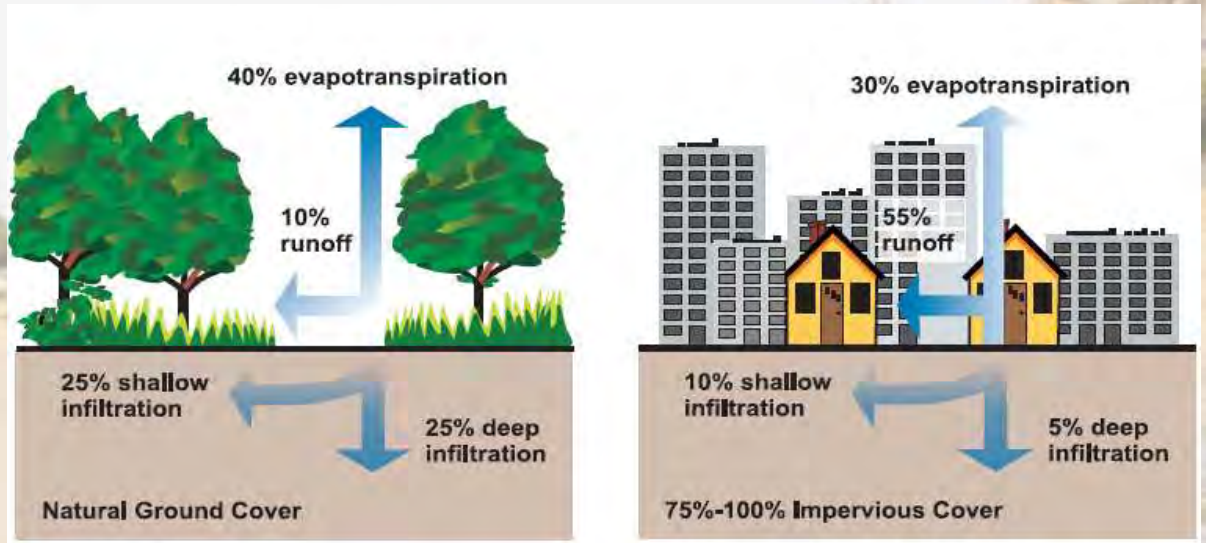


Sloped to street

Storm drain system

Urban Monitoring Program

1) Why monitor urban runoff?



Water enters urban creeks rapidly, little percolation

Non-target organisms

Designed to kill

Urban Monitoring Program

2) What should be monitored?
   - Pre-2012 – “best professional judgement”
   - Current: Prioritization Program

3) Where to monitor?

Urban Monitoring Program

2) What should be monitored?

- Pre-2012 – "best professional judgement"

Pesticide	Use (lbs)	Use score	US EPA Benchmark (ppb)	Tox score	Final score	Recom
Permethrin	27,665	5	0.01	7	35	TRUE
Bifenthrin	27,842	5	0.075	6	30	TRUE
Cyfluthrin	8,667	4	0.0125	6	24	TRUE
Diuron	21,010	5	2.4	4	20	TRUE
Fipronil	8,095	4	0.11	5	20	TRUE
Pendimethalin	19,251	4	5.2	4	16	TRUE
Bromacil	12,643	4	6.8	4	16	TRUE
Prodiamine	6,631	4	3	4	16	TRUE
Cypermethrin	4,296	3	0.195	5	15	TRUE
Sulfometuron	2,282	3	0.48	5	15	TRUE
Carbaryl	2,081	3	0.85	5	15	TRUE
Oxyfluorfen	1,665	3	0.29	5	15	TRUE
Malathion	1,363	3	0.3	5	15	TRUE
λ-Cyhalothrin	827	2	0.0035	7	14	TRUE
Triclopyr	16,939	4	70	3	12	TRUE
Oryzalin	12,271	4	15.4	3	12	TRUE
Imidacloprid	7,720	4	35	3	12	TRUE
Chlorfenapyr	1,556	3	2.915	4	12	TRUE

3) Where to monitor?

- Current: Prioritization Program

Urban Monitoring Program

2) What should be monitored?

- Pre-2012 – "best professional judgement"

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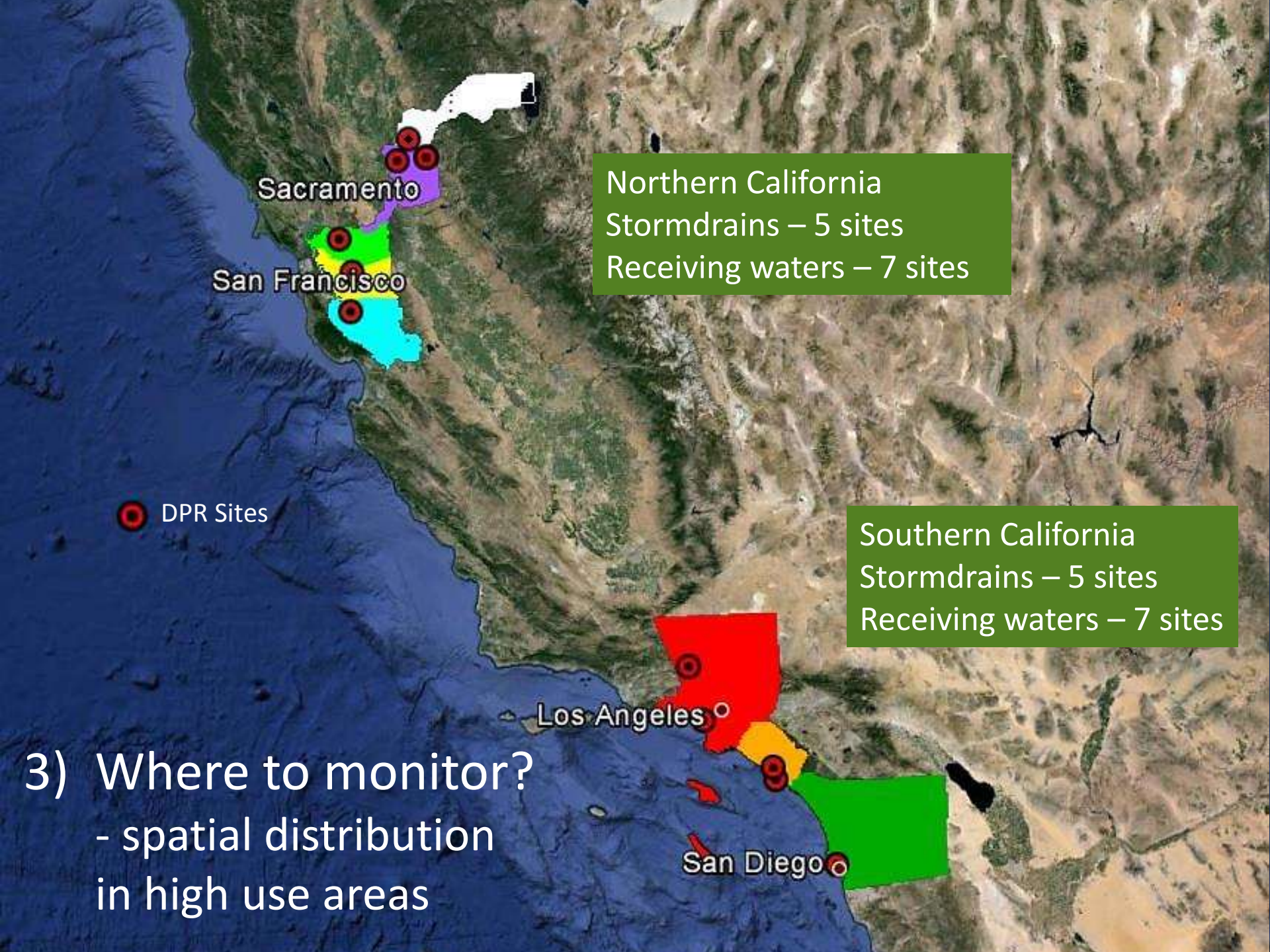
3) Where to monitor?

- Current: Prioritization Program



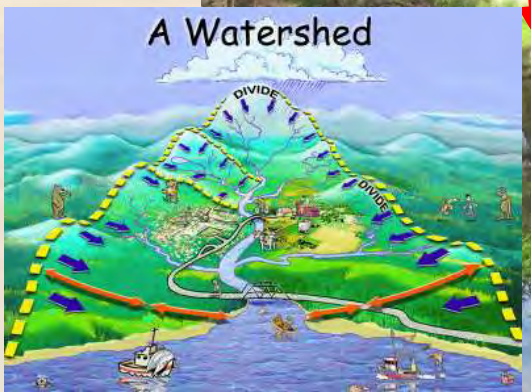
3) Where to monitor?

- spatial distribution in high use areas

3) Where to monitor?

Receiving Water

Stormdrain Outfall



Urban Monitoring Program

4) When to monitor?

Dry Season
> Higher Annual Mass Loading

Storm Event
> Higher Detection Frequencies and Concentrations

Urban Monitoring Program

5) How - what methods?

Grab Sampling - Water

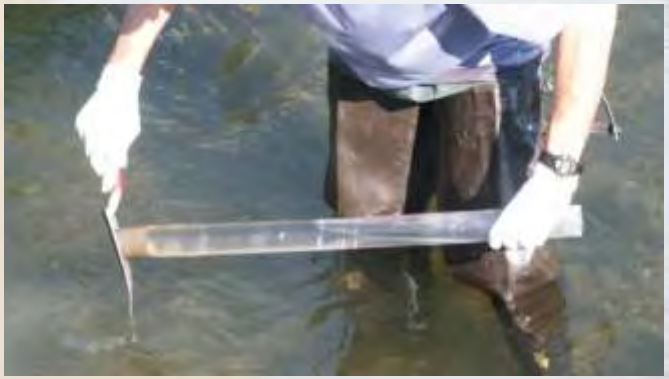
Urban Monitoring Program

5) How - what methods?

Automated Samplers

Urban Monitoring Program

5) How - what methods?



Grab Sampling - Sediments

Urban Monitoring Program

5) How - what methods?

Water Quality Measurements

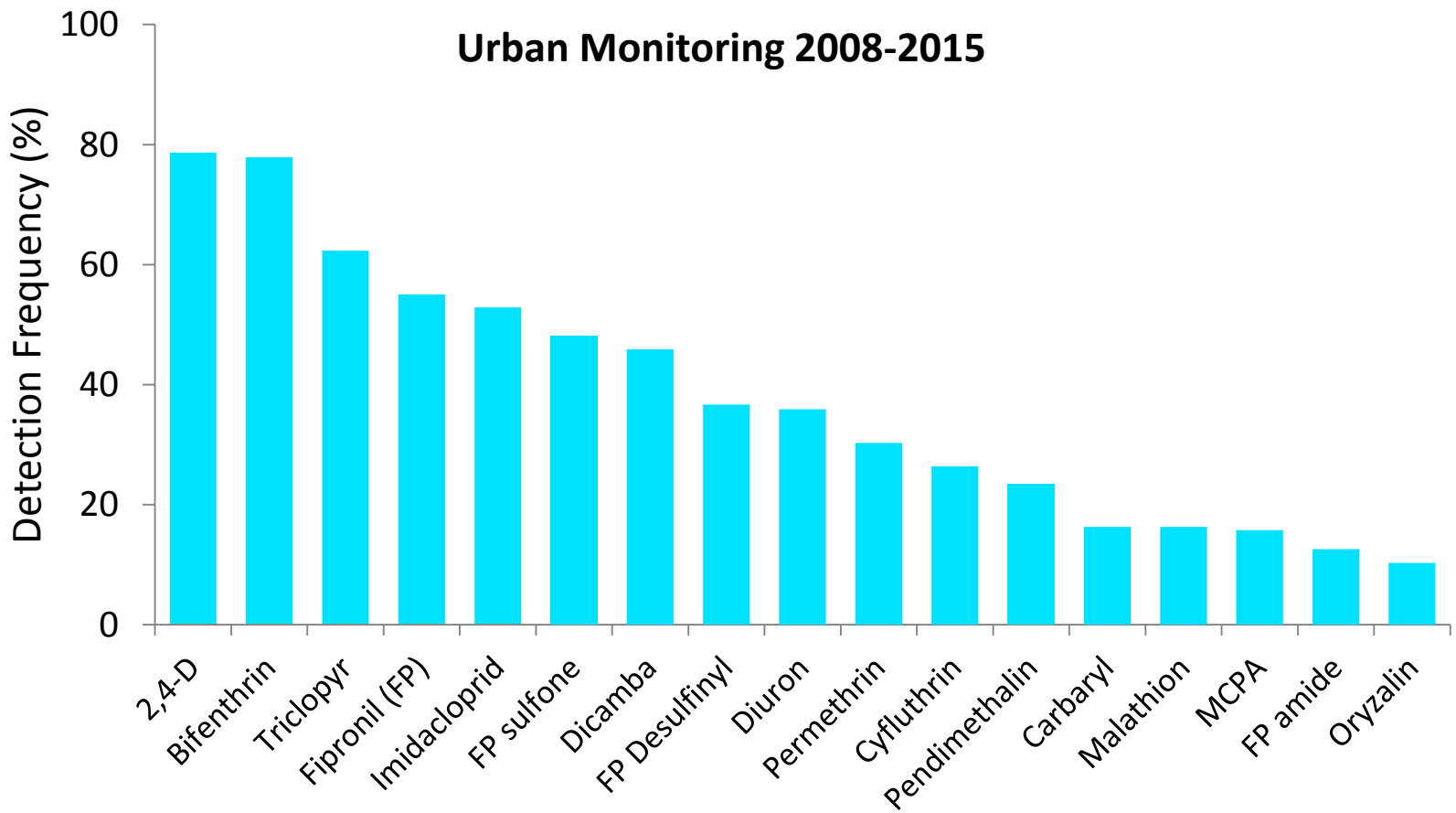
Surface Water Protection Program Video:

(view on YouTube at this link)

http://bit.ly/1MtjtnV

Urban Monitoring Program

6) What does it all mean (or, how is the data used)?



- Concerns of highly detected, potential toxic pesticides

Urban Monitoring Program

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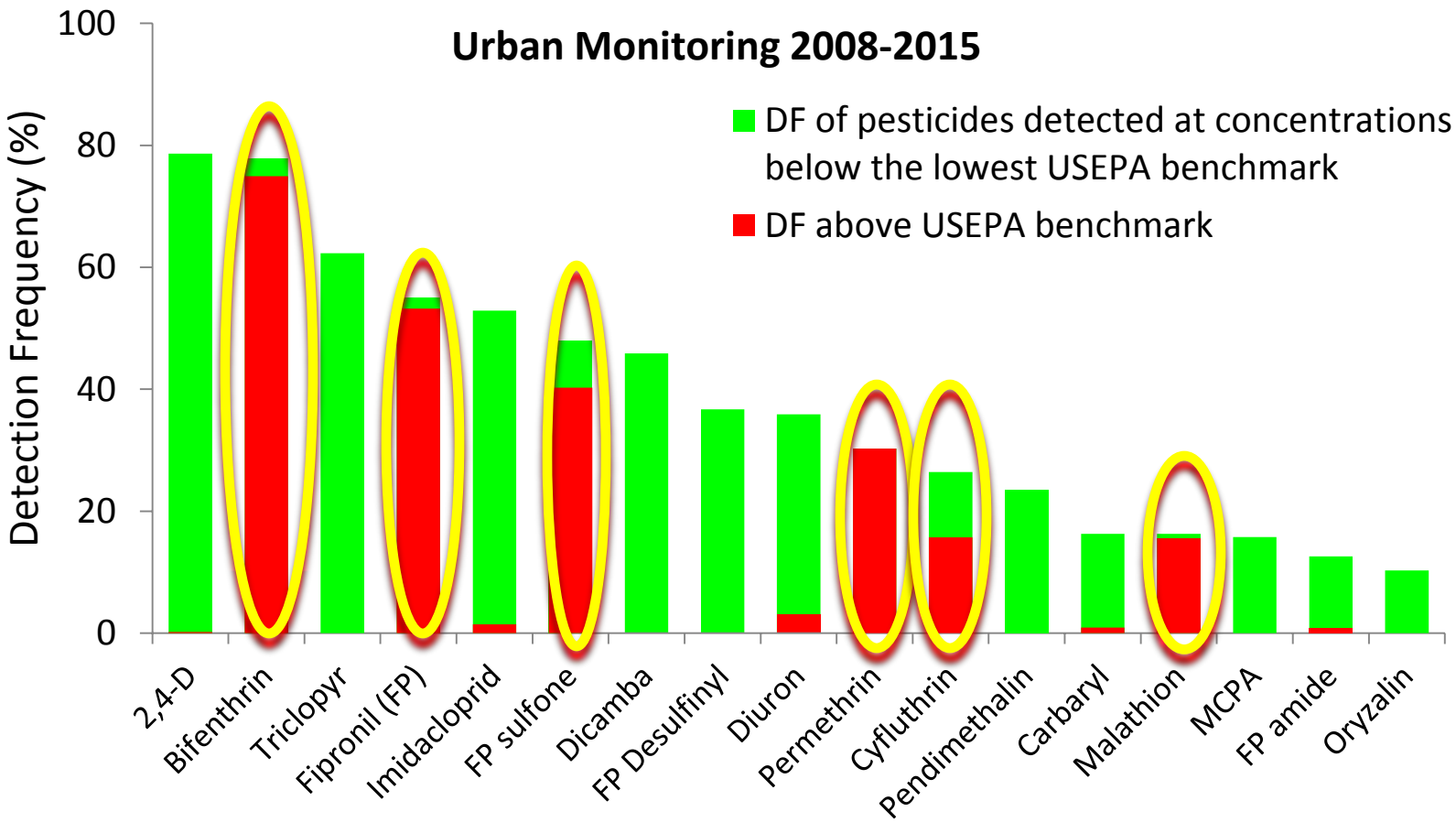
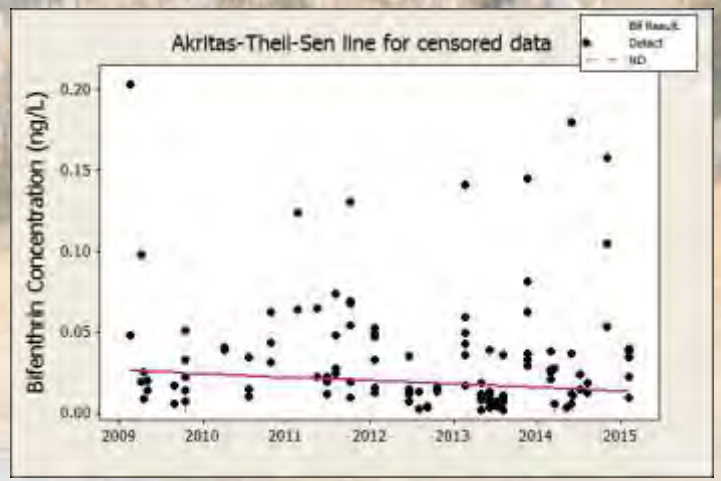


- Concerns of highly detected, potential toxic pesticides

Urban Monitoring Program

6) What does it all mean (or, how is the data used)?

- Trend analysis: PY regulations effective (bifenthrin)?



- Data Availability

Special Studies

Aquatic Toxicity

UC Davis Aquatic Health Program

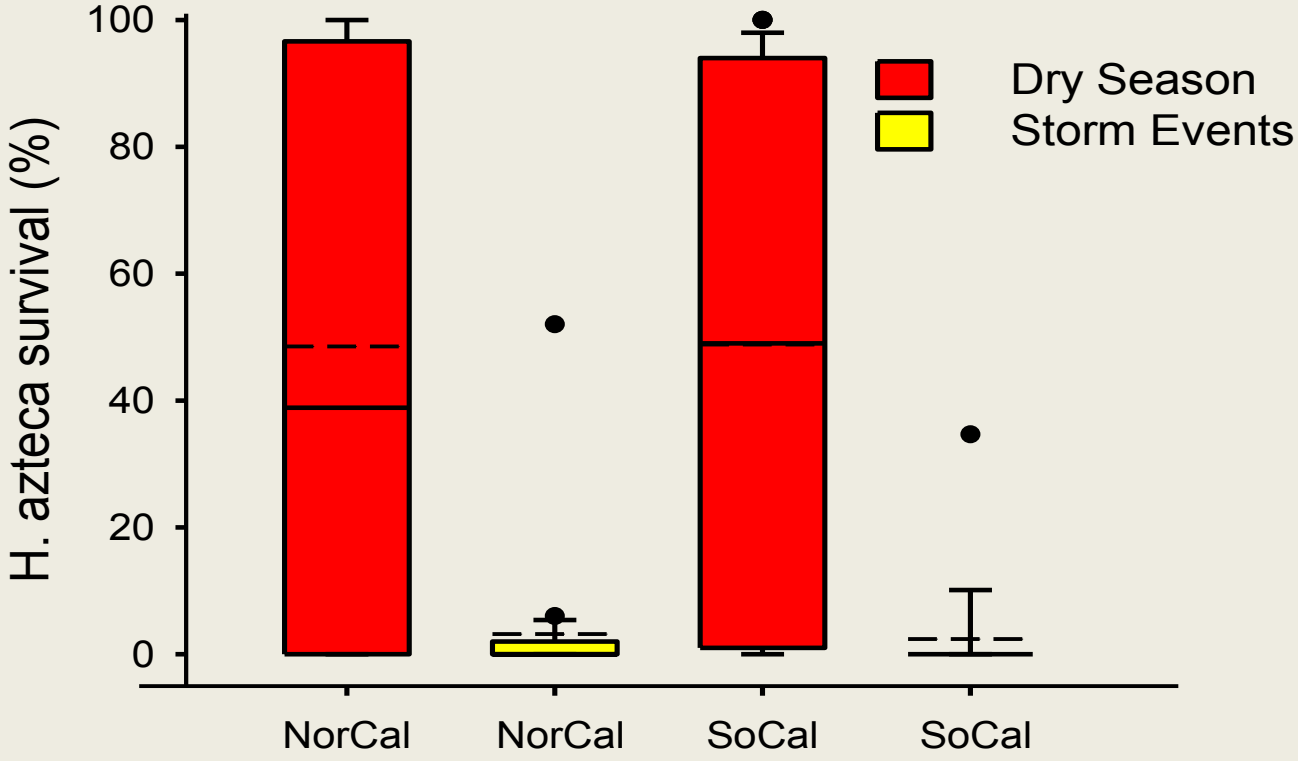
Hyalella azteca

96-hour Exposure

Percent Survival

Aquatic Toxicity

H. azteca

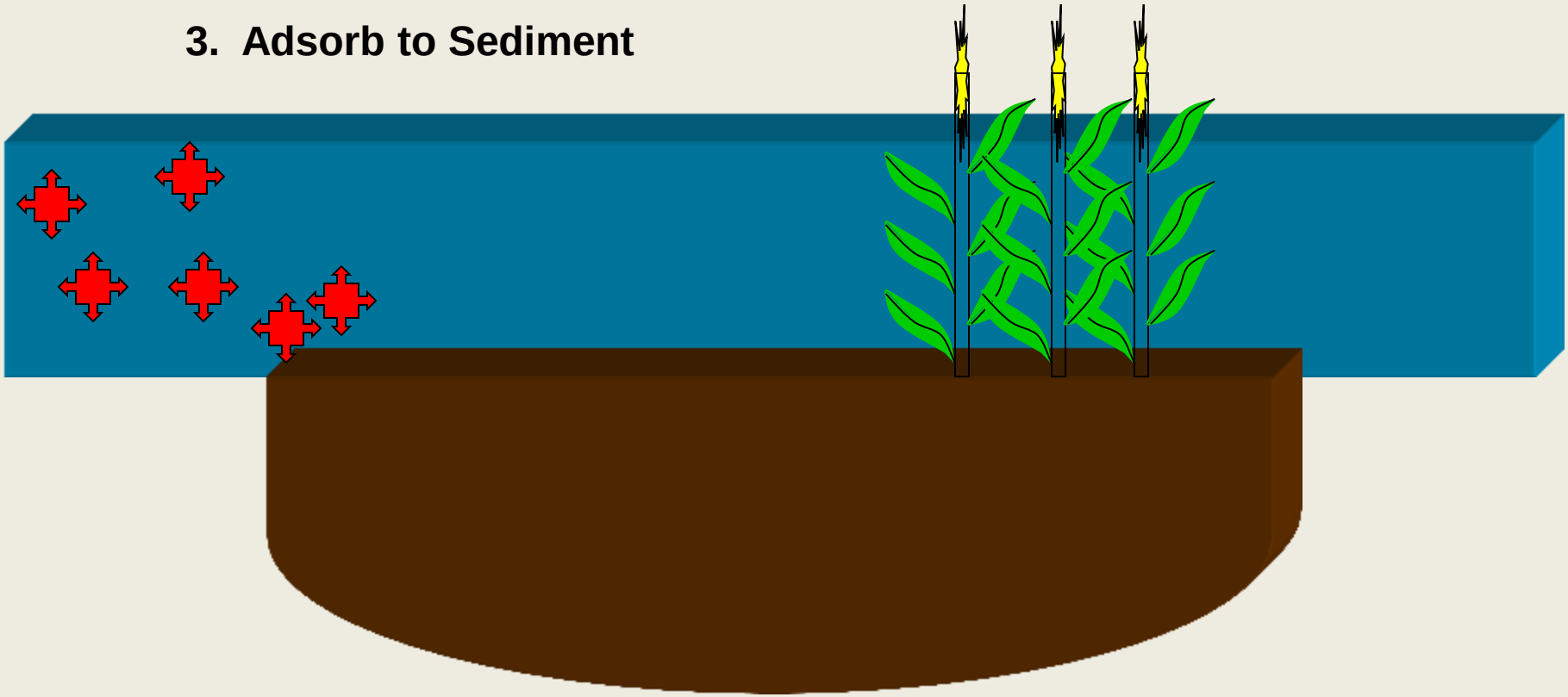


Mitigation Strategies

- Optimized conditions for pesticide removal
- Examples
  - Constructed Wetlands
  - Vegetated Ditches
  - Filters
    - Activated charcoal
    - Biochar
    - Plastic

Potential Fate of Pesticides

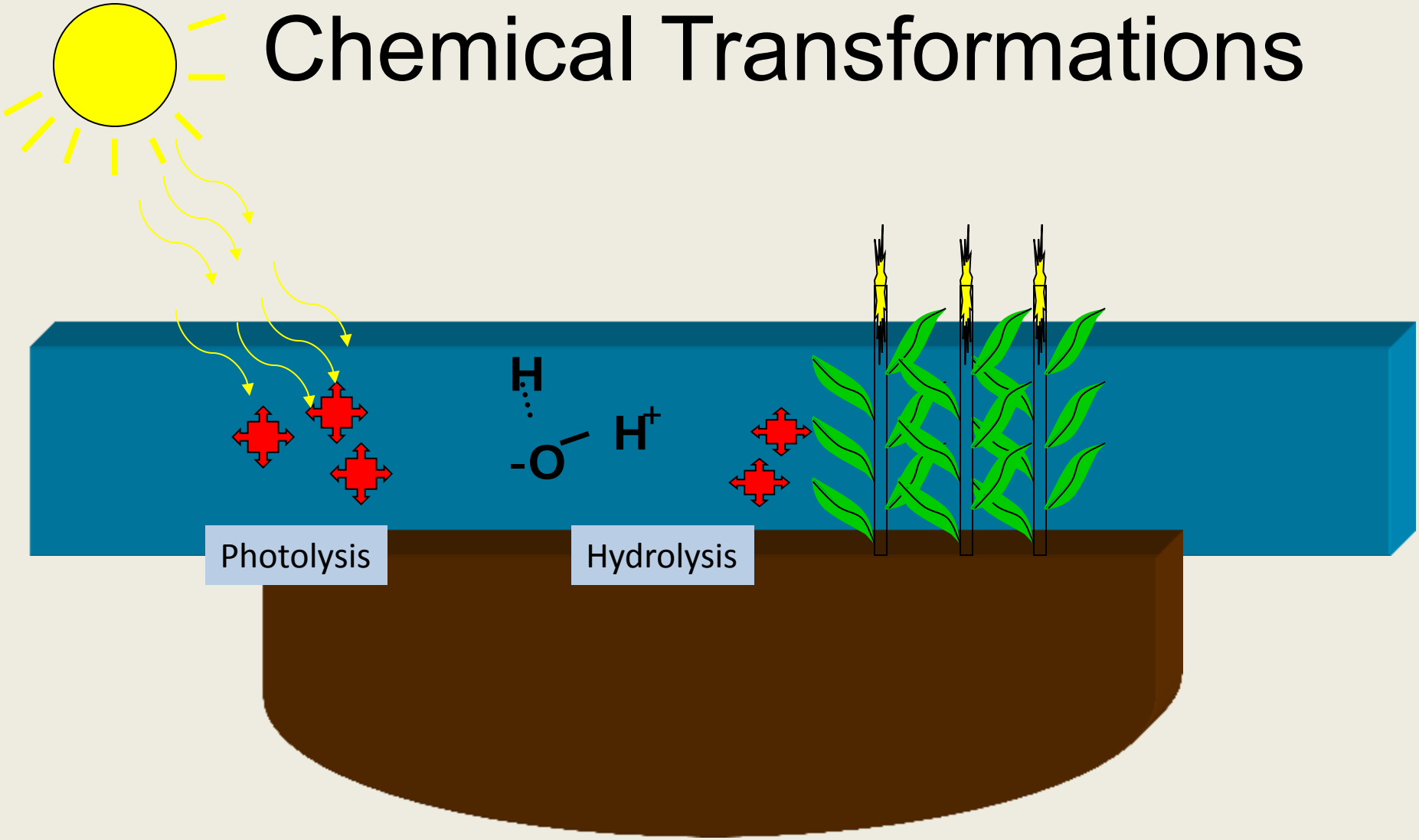
1. **Flow Through System**
2. **Associate with Vegetation**
3. **Adsorb to Sediment**



Maximize sorption sites

Pesticide

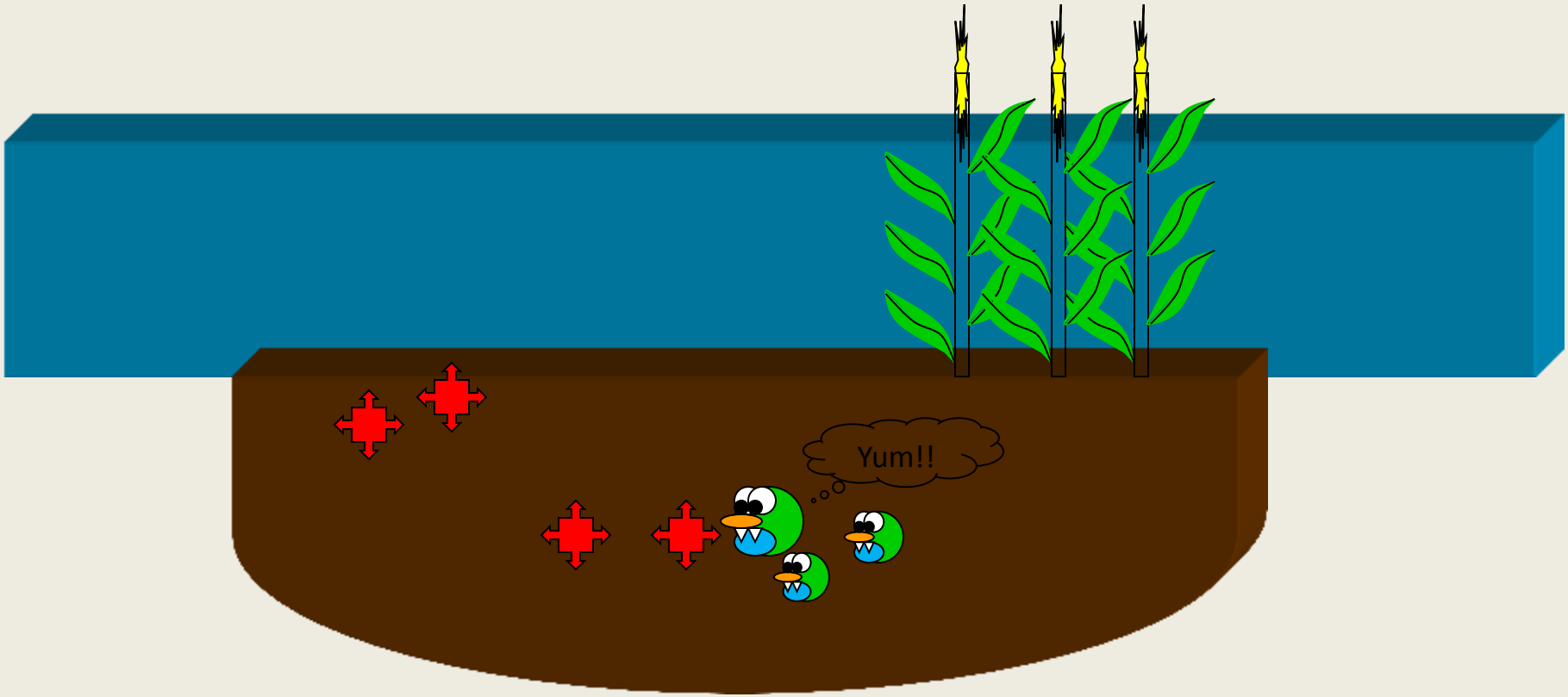
Chemical Transformations



Slower flow allows for more transformations

Pesticide

Degradation



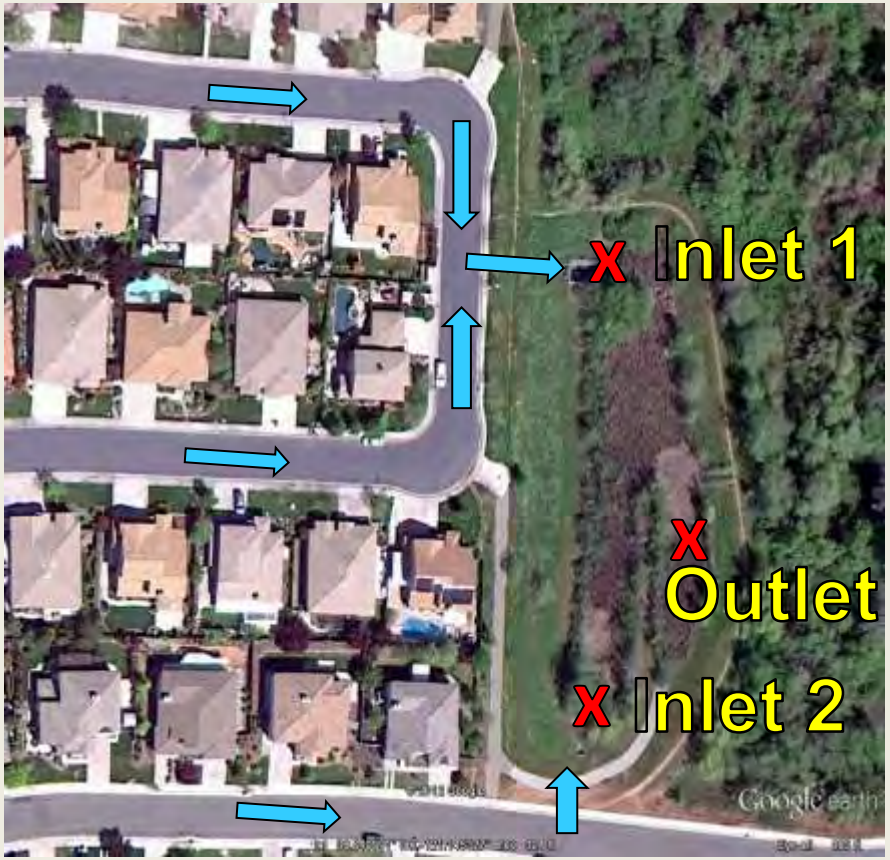
Established microbial communities

Pesticide

Mitigation

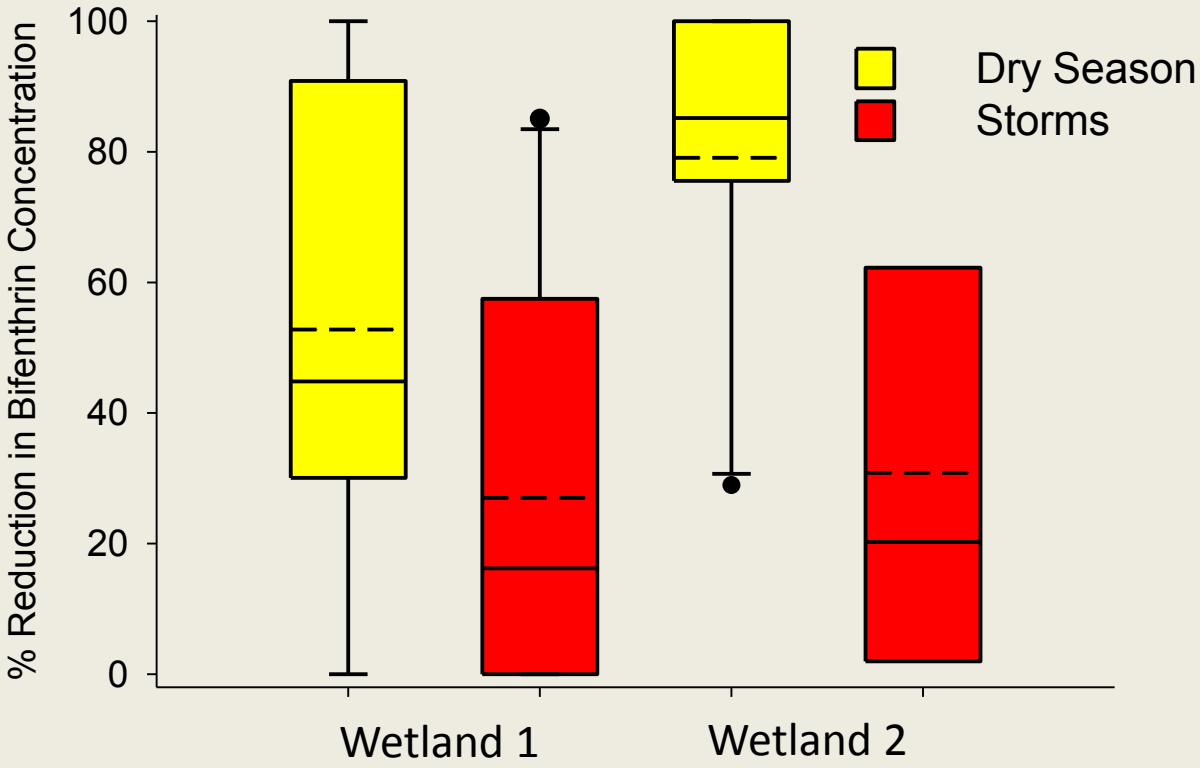
Objective: evaluate efficacy of wetlands to reduce concentrations and toxicity

Wetland 1



Wetland 2

Bifenthrin in Wetlands



$$\% \text{ Reduction} = \frac{\text{Outlet concentration}}{\text{Inlet concentration}} \times 100$$

Observations with higher outlet concentrations set to zero

Website:

http://www.cdpr.ca.gov/docs/emon/surfwtr/