Department of Pesticide Regulation
Environmental Monitoring
1001 I Street
Sacramento, California 95814
September 2002

STUDY #210: REVISED PROTOCOL FOR BIOLOGICAL ASSESSMENT IN THE SACRAMENTO AND SAN JOAQUIN WATERSHEDS (FALL 2002 THROUGH SPRING 2004)

I. INTRODUCTION

One goal of the Department of Pesticide Regulation's (DPR's) Surface Water Protection Program is to prevent the off-site movement of pesticides to surface water bodies, including rivers, streams, and agricultural drains. This is done by characterizing pesticide residues in these surface waters and developing site-specific ways to keep the pesticides out of surface waters (DPR, 2001).

Currently, chemical surface water monitoring and toxicity testing using one species has been the primary method to determine the presence and aquatic toxicity of pesticides, but this may not always take the following into consideration:

- Pesticide inputs to surface water commonly occurs as pulses
- Occasional monitoring may miss the pulse
- Laboratory toxicity tests do not assess ecological impacts

Bioassessment uses the biological community instead of one species, which may allow more accurate determination of the health of a water system. The variety of species and population sizes present in the stream or creek are reflective of the overall health of that biological community and can be used as a water quality indicator by State Water Resources Control Board (SWRCB, 2001). The use of this biological community, along with physical habitat assessment, can help us determine the integrity or current condition of a water body (Harrington and Borne, 1999). This information may be useful in identifying impaired water bodies and may lead to further evaluation of bioassessment as a tool for evaluating management practices and mitigation measures to prevent offsite movement of pesticides.

In a joint effort DPR will collaborate with the Central Valley Regional Water Quality (CVRWQCB) and assist them with their bioassessment monitoring and data collection needs. This project is part of DPR operation plan (1,1,2,4): Coordinate, develop methodology, and complete pilot project on bioassessment of two watersheds.

II. OBJECTIVE

One objective of this project is to enable staff to become familiar with bioassessment equipment and develop effective bioassessment and physical habitat monitoring skills. This project will be used as a pilot program to assist in the development of a potential bioassessment monitoring program. Another objective is to establish baseline aquatic biological community structure and physical habitat conditions in wadeable, agriculture dominated surface waters.

It is important to compare site-monitoring data to natural or "reference" sites. It is necessary to establish normal or "best available" measures of biological community health in order to accurately determine if there has been a negative impact. Reference sites for the lower San Joaquin watershed will be researched and determined in a separate study plan (Protocol #209, currently being developed). Bidwell Institute of California State University, Chico is currently developing reference sites for the lower Sacramento River for the CVRWQCB.

III. PERSONNEL

This study will be conducted by staff from the Environmental Monitoring Branch, Agriculture Program under the general direction of Kean Goh, Agricultural Program Supervisor IV. Key personnel are listed below:

Project Leader:	Juanita Bacey
Field Coordinator:	Heather Casjens
Senior Scientist:	Frank Spurlock
Consulting Scientist:	Jim Harrington, Department of Fish and Game
Laboratory Liaison:	Carissa Ganapathy
Taxonomists:	Bidwell Institute
Chemists:	CDFA

Questions concerning this monitoring project should be directed to Juanita Bacey, Environmental Research Scientist, at (916) 445-3759.

IV. STUDY PLAN

This project will target areas of concern, and sites will be selected using the following criteria:

- Sites receive drainage from agriculture runoff
- History of previous pesticide detections
- Need for current condition evaluation

In cooperation with CVRWQCB, DPR will monitor and assess not more than 10 sites in the Sacramento and San Joaquin watershed. Monitoring will occur in the fall and spring for two consecutive years in order to collect information on seasonal variation.

Habitat modifications and pesticides can be stressors and indicators of benthic macroinvertebrate (BMI) drift and, therefore, a physical habitat assessment will be completed for each reach sampled. Water samples will also be collected from each sampling site. These samples will be analyzed for selected organophosphates (OPs), esfenvalerate and permethrin (PY), and selected triazines (TRs). Some of these pesticides have been previously detected in these water systems during dormant application runoff periods.

V. BMI SAMPLING METHOD

Sampling will follow Standard Operating Procedure (SOP) # FSWA010.00, Instructions for sampling BMI in wadeable waters using the multi-habitat method (Non-point source). Each site or reach will be determined based on available access, using a non-point source design. If there is any disagreement in determining exact sampling sites or sampling procedures, U.S. Environmental Protection Agency (U.S. EPA) guidelines will take precedent (U.S. EPA, 2001).

IV. PHYSICAL HABITAT ASSESSMENT METHOD

Habitat assessment will be evaluated following the physical habitat scoring criteria as described in the California Stream Bioassessment Procedure (Figure 1) and also using a modified U.S. EPA Physical Characterization/Water Quality Field Data sheet (Figure 2). This is based on U.S. EPA national standardized methods. One assessment will be completed at each reach sampled. In addition, the following will be measured at each BMI sampling site: Global Positioning System coordinates of location, riffle length, transect width and depth, velocity, canopy cover, substrate complexity, riffle gradient or slope, water temperature, dissolved oxygen, pH, and conductivity (Figure 2).

V. WATER SAMPLING METHOD

Water samples will be collected at the furthest downstream site of each reach. Four samples will be individually collected per reach for each chemical screen. All samples collected will be grab samples consisting of a 1-liter amber glass bottle on a grab pole, collected from center channel. The amber bottles will be sealed with Teflon-lined lids.

Samples will be transported and stored on wet ice or refrigerated at 4^{o}C until extraction for chemical analysis. Dissolved oxygen, pH, specific conductivity, and water temperature will be measured *in situ* at each site as described in section IV. Water monitoring will be conducted as described in SOP FSWA002.0 and SOP QAQC004.01.

VI. SEDIMENT SAMPLING METHOD

Sediment samples will also be collected and analyzed for esfenvalerate and permethrin. For the 10 sites there will be a total of 10 sediment samples. Sediment samples will be collected using a 24 inch long, by 2 inch diameter, polycarbonate cylinder tube, and a 4 inch putty knife. One end of the tube will be thrust into the sediment and then removed. The top 2 inches of the sediment collected in the tube will be placed into a wide mouth polycarbonate container. This will be repeated 2 times so that each sample will be a composite of 3 grabs.

VII. MACROINVERTEBRATE AND CHEMICAL ANALYSIS

Bidwell Environmental Institute, California State University, Chico will perform macroinvertebrate identification. Quality control will be conducted in accordance with previously established Bidwell procedures, which have been approved by DPR (DFG QC SOP). A sub-sample of 300 macroinvertebrates will be identified to genera and, when possible, to species.

Chemical analyses will be performed by the California Department of Food and Agriculture's Center for Analytical Chemistry. Quality control will be conducted in accordance with SOP QAQC001.00 (Segawa, 1995). Ten percent of the total number of analyses will be submitted with field samples as field blanks and blind spikes. The following will be used to determine concentrations of pesticides:

- Ops - GC/FPD - gas chromatography/flame phometric detector
- Pyrethroids - GC/ECD - gas chromatography/electron capture detector
- Pyrethroids (in sediment) – GC/ECD, confirmed with GC/MSD
- Triazines - APCI/LC/MS/MS – atmospheric pressure chemical ionization/liquid chromatography/mass spectrometry
- Comprehensive chemical analytical methods will be provided in the final report. The reporting limit is the lowest concentration of analyte that the method can
- detect reliably in a matrix blank. Method titles and reporting limits are reported in Table 1.

VIII. DATA ANALYSIS

Macroinvertebrate analysis procedures are based on the EPA's multi-metric approach to bioassessment data analysis. A taxonomic list of the BMI's identified in each sample will be generated along with a table of sample values and means. Variability of the sample values will be expressed as the coefficient of variability (%CV).

Concentrations of insecticides in water will be reported as parts per billion (ppb) by the laboratory and as micrograms per liter (µg/L) in the final report. The frequency of detection will determine how the monitoring data is analyzed. If there are only a few non-continuous, detections (i.e. < 10%), data analysis will focus on event caused detections. Non-continuous sources will be examined, such as storm events, high application rates applied recently, and irrigation practices. Data of rainfall events and pesticide uses will be obtained to analyze the potential relationship between event characteristics and surface water quality.

If the detection frequency if sufficiently high, estimation of mass loading will be attempted.

IX. TIMETABLE

Field Sampling:	Fall 2002, Spring and Fall 2003, Spring 2004
Memorandums:	December 31, 2003, and December 31, 2004
Final Report:	June 31, 2005

X. BUDGET

<u>Bioassessment Analysis</u>				
BMI identification (separate budget, under contract)				$ 0
<u>Chemistry Analysis</u>	<u>Cost at $300/sample</u>			
OPs	1 samples x 10 sites x 2 sampling periods (spring & fall)	20 samples	=	6,000
Esfenvalerate and Permethrin	1 samples x 10 sites x 2 sampling periods (spring & fall)	20 samples	=	6,000
Pyrethroids (Sediment)	1 samples x 10 sites x 2 sampling periods (spring & fall)	20 samples		6,000
Triazines	1 samples x 10 sites x 2 sampling periods (spring & fall)	20 samples	=	6,000
<u>Quality Control</u>				
Blind spikes	2 samples x 3 analysis	6 samples	=	1,800
Field blanks	2 samples x 3 analysis	6 samples	=	1,800
Total				**$ 27,600**

<u>Personnel Services</u>		
Env. Scientist	$25/hr. at 6 days/10 sites x 2 seasons	$2,400
Senior Scientist	Separate budget, under contract	$ 0
Staff benefits	(31%)	744
Scientific Aide	$11/hr. at 6 days/10 sites x 2 seasons	$ 1056
Staff benefits	(11%)	$116
Overtime		0
Overhead	(20%)	$863
Total		**$5,180**
<u>Operating expenses</u>		
Per diem and lodging	6 days x $100/day x 2 seasons x 2 staff	$2,400
Transportation	$0.34/mi at 75 miles/day x 6 days x 2 seasons	$ 306
Field supplies - Equipment	Ethyl alcohol, ice, misc.	$500
Total		**$3,206**
TOTAL	**PER FISCAL YEAR**	**$35,986**

XI. REFERENCES

California Department of Pesticide Regulation. 2001. Regulating Pesticides: The California Story. A guide to pesticide regulation in California. October 2001.

Department of Pesticide Regulation (DPR), 2000. Pesticide Use Database.

Harrington, J. and M. Born. 1999. Measuring the Health of California Streams and Rivers. Sustainable Land Stewardship Int'l. Inst.

Segawa, R. 1995. Chemistry laboratory quality control. [Online] <http://www.cdpr.ca.gov/doc/empm/pubs/sops/qaqc001.pdf>.

State Water Resources Control Board. 2001. The California Streamside Biosurvey. An introduction to using aquatic invertebrates as water quality indicators. September, 2001.

U.S. Environmental Protection Agency. 2001. Environmental monitoring and assessment program – surface waters: Western pilot study field operations manual for wadeable streams. April 2001.

TABLE 1. CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE, CENTER FOR ANALYTICAL CHEMISTRY ORGANOPHOSPHATE AND TRIZINE/HERBICIDE PESTICIDES.

Organophosphate Pesticides in Surface Water Method: GC/FPD		Organophosphate Pesticides in Surface Water Method: GC/FPD		Triazines/Herbicides in Surface Water Method: APCI/LC/MS/MS	
Compound	**Reporting Limit (µg/L)**	**Compound**	**Reporting Limit (µg/L)**	**Compound**	**Reporting Limit (µg/L)**
Azinphos methyl	0.05	Phosmet	0.05	Atrazine	0.05
Chlorpyrifos	0.04	Thimet (Phorate)	0.05	Bromacil	0.05
Diazinon	0.04	Profenofos	0.05	Diuron	0.05
DDVP (dichlorvos)	0.05	Tribufos	0.05	Hexazinone	0.05
Dimethoate	0.04			Metribuzin	0.05
Disulfoton	0.04			Norflurazon	0.05
Ethoprop	0.05			Prometon	0.05
Fenamiphos	0.05			Prometryn	0.05
Fonofos	0.04			Simazine	0.05
Malathion	0.04			DEA	0.05
Methidathion	0.05			ACET	0.05
Methyl Parathion	0.03			DACT	0.05

Pyrethroid Pesticides in Surface Water Method: GC/ECD		Pyrethroid Pesticides in Sediment Method: GC/ECD, confirmed with GC/MSD	
Compound			**(µg/g)**
Esfenvalerate	0.05	Esfenvalerate	0.01
Permethrin	0.05	Permethrin	0.01

Figure 1a

PHYSICAL HABITAT QUALITY
(California Stream Bioassessment Procedure)

WATERSHED/ STREAM: ____________________ DATE/ TIME: ____________________

COMPANY/ AGENCY: ____________________ SAMPLE ID NUMBER: ____________________

SITE DESCRIPTION: ____________________

Circle the appropriate score for all 20 habitat parameters. Record the total score on the front page of the CBW.

Parameters to be evaluated within the sampling reach

HABITAT PARAMETER	CONDITION CATEGORY			
	OPTIMAL	**SUBOPTIMAL**	**MARGINAL**	**POOR**
1. Epifaunal Substrate/ Available Cover	Greater than 70% (50% for low gradient streams) of substrate favorable for epifaunal colonization and fish cover; most favorable is a mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% (30-50% for low gradient streams) mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% (10-30% for low gradient streams) mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% (10% for low gradient streams) stable habitat; lack of habitat is obvious; substrate unstable or lacking.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/ Depth Regimes *(deep<0.5 m, slow<0.3 m/s)*	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow).	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/ depth regime (usually slow-deep).
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% (<20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Figure 1b

Parameters to be evaluated in an area longer than the sampling reach

HABITAT PARAMETER	CONDITION CATEGORY			
	OPTIMAL	SUBOPTIMAL	MARGINAL	POOR
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left of right side by facing downstream	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zones covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities haveimpacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Figure 2a

Physical Characterization/Water Quality Field Data Sheet

Study #: ______________________________ **Date/Time:**__________________________

Sampling Crew: _______________________ **Location:** ___________________________

Weather Conditions:

____

GPS Coordinates		***Site Information***	
Lat:	____________________	Reach Length:	__________
Long:	____________________	Physical habitat	__________
Elevation:	____________________	quality score:	__________
Ecoregion	____________________	% canopy cover:	__________

Sample #s		Water Quality	
OP	________	Temperature	__________
DI	________	EC (µS/cm)	__________
TR	________	DO (mg/L)	__________
PY	________	pH	__________
BU	________		
Macroinvertebrate	________		
Sediment	________		

Water Odors: (i.e. normal, fishy, sewage)

____

Water Surface Oils: (i.e. slick, sheen, globs, flecks, none)

____

Turbidity: (i.e. clear, slightly turbid, turbid, opaque, stained)

____

Comments:

____

____

____

____

Figure 2b

Habitat Types (Indicates the % of each habitat type present)

Cobble ______ Submerged macrophytes ______
Snags ______ Gravel ______
Sand and fine sediment ______ Mud ______
Vegetated Banks (undercuts & overhangs) ______ Other ______

Watershed features
Forest
Field/Pasture
Agricultural
Residential
Commercial
Industrial
Other

Local watershed NPS pollution
No evidence ______
Some potential sources ______
Obvious sources ______

Local watershed erosion
None ______
Moderate ______
Heavy ______

Instream features
Reach length ______ m
Stream width ______ m
Sampling reach area ______ m^2
Area in km^2 (m^2x1000) ______ km^2

Stream depth ______ m
Surface velocity ______ m/sec
(at thalweg) ______
(feet x 0.3048m = meters)
(yards x 0.9144m = meters)

Aquatic vegetation (Indicate the dominant type and record the dominant species present)
Rooted emergent ______ Free floating ______
Rooted submergent ______ Floating algae ______
Rooted floating ______ Attached algae ______

Dominant species present ______
Portion of the reach with aquatic vegatation ______ %

Inorganic substrate components (should add up to 100%)			Organic substrate components (does not necessarily add up to 100%)		
Substrate type	Diameter	% Composition in sampling reach	Substrate type	Characteristic	% Composition in sampling area
Bedrock			Detritus	Sticks, wood, coarse plant materials (CPOM)	
Boulder	>256 mm(10”)				
Cobble	64-256mm(2.5-10”)		Muck-mud	Black, very fine organic (FPOM)	
Gravel	2-64mm(0.1-2.5”)				
Sand	0.06-2mm(gritty)		Marl	Grey, shell fragments	
Silt	0.004-0.06mm				
Clay	<0.004mm (slick)				

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AMENDMENT TO STUDY #210:

PROTOCOL FOR BIOLOGICAL ASSESSMENT IN THE SACRAMENTO AND SAN JOAQUIN WATERSHEDS (FALL 2002 THROUGH SPRING 2004)

One objective of this project is to enable staff to become familiar with bioassessment equipment and develop effective bioassessment and physical habitat monitoring skills. The sites selected in this protocol have been surveyed for two seasons (Fall 2002 and Spring 2003) using a modified EPA multi-habitat method. This method was chosen as the preferred method used by the Central Valley Regional Water Quality Control Board (CVRWQCB) for the past year.

In the developing of "reference" sites for the San Joaquin valley (Protocol #209), it has been recommended by the CVRWQCB that these reference sites and all future sampling in Region 5 be sampled using the modified EPA EMAP multi-habitat method. This is believed to better reflect the physical habitat and anthropogenic impacts found in areas such as the San Joaquin Valley.

Therefore, for the final two seasons of sampling (Fall 2003 and Spring 2004), field crews will use the modified EPA EMAP method (SOP FSWA015.00).