CENTRAL VALLEY REGIONAL
WATER QUALITY CONTROL BOARD

AMENDMENTS TO THE WATER QUALITY CONTROL PLAN FOR THE SACRAMENTO RIVER AND SAN JOAQUIN RIVER BASINS

FOR

THE CONTROL OF DIAZINON AND CHLORPYRIFOS RUNOFF INTO THE LOWER SAN JOAQUIN RIVER

APPENDIX E
CRITERIA CALCULATIONS FOR DIAZINON AND CHLORPYRIFOS
FINAL STAFF REPORT

October 2005

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

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This publication is a report by staff of the California Regional Water Quality Control Board, Central Valley Region. This report contains the evaluation of alternatives and technical support for the adoption of an amendment to the Water Quality Control Plan for the Sacramento and San Joaquin River Basins(Resolution No. R5-2005-0138). Mention of specific products does not represent endorsement of those products by the Regional Board.

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Appendix E

Criteria Calculations for Diazinon and Chlorpyrifos

Water Quality Criteria Calculations

This section provides a detailed description of the calculations performed using the U.S. EPA's methodology (1985) for deriving aquatic life criteria. Diazinon criteria were derived using the toxicity datasets (Table 1) identified as valid by the California Department of Fish and Game (Siepmann and Finlayson, 2000; Finlayson, 2004) and by U.S. EPA's contractor (University of Wisconsin-Superior and Great Lakes Environmental Center, 2000). In performing these calculations, the *Gammarus fasciatus* study results were removed from both of these datasets, based on the recommendation of Finlayson (2004) and evaluation of the available *Gammarus fasciatus* data sheets by the Regional Board (Pinkos, 2004).

The chlorpyrifos criteria were derived using the toxicity dataset (Table 2) identified as valid by the California Department of Fish and Game (Siepmann and Finlayson, 2000).

The U.S. EPA methodology uses only the lowest four Genus Mean Average Values (GMAVs) directly in the criteria derivation. The total number of GMAVs affects the percentile rankings of the lowest four GMAVs. Table 3 provides all of the intermediate calculations from application of the U.S. EPA methodology to the three datasets. The intermediate calculations are rounded to four significant figures. The final criteria values are rounded to two significant figures. The number of significant figures for the intermediate values and final criteria follow the U.S. EPA guidelines.

Table 3 also shows the results of the calculations performed by the Regional Board on the CDFG and U.S. EPA contractor data sets. The Regional Board's calculations result in the same diazinon criteria as calculated by CDFG (Finlayson, 2004). The Regional Board's calculated chlorpyrifos criteria are slightly higher than the CDFG calculated acute criterion (0.025 v. 0.02 μg/L) and chronic criterion (0.015 v. 0.014 μg/L). The differences in the results are likely due to differences in rounding. CDFG rounded the final acute values (FAVs) of diazinon and chlorpyrifos to either one or two significant figures and the Regional Board rounded the FAVs to four significant figures.

Use of the U.S. EPA contractor's diazinon data set versus CDFG's data set results in nearly identical FAVs and acute criterion (0.15 v. 0.16 μg/L). The difference in the chronic criterion (0.15 v. 0.10 μg/L) is due to the use of different acute to chronic ratios (ACRs) – an ACR of 2 was used by U.S. EPA's contractor and an ACR of 3 was used by CDFG. The ACR calculated by CDFG was preferred, since CDFG included three sensitive species in their calculation of the ACR (versus two by the US EPA contractor) and CDFG calculated ACRs based on toxicity test results from the same studies or at least the same laboratory.

The results of the U.S. EPA contractor's diazinon criteria calculations are not directly comparable to Regional Board calculations, since those calculations included the *Gammarus fasciatus* study results.

Table 1. Diazinon Genus Mean Acute Values Used by Siepmann and Finlayson (2000) and University of Wisconsin-Superior and Great Lakes Environmental Center (2000)[1]

University of Wisconsin-Superior and Great Lakes Environmental Center, 2000		Siepmann and Finlayson, 2000	
Genus Mean Acute Value (μg/L)	**Species**	**Genus Mean Acute Value (μg/L)**	**Species**
0.3773	*Ceriodaphnia dubia*	0.44	*Ceriodaphnia dubia*
0.9020	*Daphnia magna; Daphnia pulex*	1.06	*Daphnia magna; Daphnia pulex*
1.587	*Simocephalus serrulatus*	1.59	*Simocephalus serrulatus*
6.51	*Hyalella azteca*	4.15	*Neomysis mercedis*
10.7	*Chironomous tentans*	4.41	*Physa sp.*
25	*Pteronarcys californica*	25	*Pteronarcys californica*
>50	*Rana clamitans*	272	*Lepomis macrochirus*
459.6	*Lepomis macrochirus*	441	*Oncorhynchus clarki Oncorhynchus mykiss*
660	*Salvelinus fontinalis Salvelinus namaycush*	660	*Salvelinus fontinalis Salvelinus namaycush*
800	*Poecilia reticulata*	800	*Poecilia reticulata*
960.4	*Oncorhynchus clarki Oncorhynchus mykiss*	1,643	*Jordanella floridae*
1,643	*Jordanella floridae*	7,804	*Pimephales promelas*
3,198	*Pomacea paludosa*	8,000	*Brachydanio rerio*
7,841	*Lumbricus variegatus*	29,200	*Brachionus calyciflorus*
8,000	*Brachydanio rerio*		
8,641	*Pimephales promelas*		
9,000	*Carassius auratus*		
11,000	*Gillia altilis*		
11,640	*Dugesia tigrina*		

[1] The *Gammarus fasciatus* study result has been removed from the data set.

Table 2. Chlorpyrifos Genus Mean Acute Values Used by Siepmann and Finlayson (2000)

Siepmann and Finlayson, 2000	
Genus Mean Acute Value (μg/L)	**Species**
0.06	*Ceriodaphnia dubia*
0.11	*Gammarus lacustris*
0.15	*Neomysis mercedis*
0.38	*Pteronarcella badia*
0.54	*Daphnia magna; Daphnia pulex*
0.58	*Claassenia sabulosa*
0.60	*Chironomus tentans*
0.80	*Petodytes sp.*
3.03	*Lepomis macrochirus*
6.0	*Orconectes immunis*
10	*Pteronarcys californica*
10.1	*Oncorhynchus clarki Oncorhynchus mykiss*
138	*Hyallela azteca*
244	*Salvelinus namaycush*
274	*Pimephales promelas*
475	*Ictalurus punctatus*
>806	*Carassius auratus*
>806	*Aplexa hypnorum*

Table 3. Results of Calculations Performed by the Regional Board on CDFG Diazinon and Chlorpyrifos Datasets and the U.S. EPA Contractor's Diazinon Data Set

Calculation Step	CDFG Diazinon Data Set	U.S. EPA Contractor Diazinon Data Set	CDFG Chlorpyrifos Data Set
Rank 1 Cumulative Probability (P) (GMAV- μg/L)	0.0667 (0.44)	0.05 (0.3773)	0.0526 (0.06)
Rank 2 Cumulative Probability (P) (GMAV- μg/L)	0.1333 (1.06)	0.10 (0.9020)	0.1053 (0.11)
Rank 3 Cumulative Probability (P) (GMAV- μg/L)	0.2 (1.59)	0.15 (1.587)	0.1579 (0.15)
Rank 4 Cumulative Probability (P) (GMAV- μg/L)	0.2667 (4.15)	0.20 (6.51)	0.2105 (0.38)
S squared	70.21	154.3	60.77
S	8.379	12.42	7.796
L	-3.043	-3.953	-4.72
A	-1.169	-1.176	-2.977
Final Acute Value(μg/L)	0.3107	0.3085	0.0509
Acute Criterion (μg/L)	**0.16**	**0.15**	**0.025**
Acute to Chronic Ratio	3	2	3.5
Final Chronic Value (μg/L)	0.1036	0.1543	0.01454
Chronic Criterion (μg/L)	**0.10**	**0.15**	**0.015**

The calculation steps are defined below. The cumulative probability (P) and associated GMAVs of the lowest four GMAVs are applied in the equations below.

$$S^2 = \frac{\sum((\ln GMAV)^2) - \frac{(\sum(\ln GMAV))^2}{4}}{\sum(P) - \frac{((\sum(\sqrt{P}))^2}{4}}$$

$$\mathrm{L} = \frac{\Sigma(\ln GMAV) - S \cdot \Sigma(\sqrt{P})}{4}$$

$$A = S(\sqrt{0.05}) + L$$

$$FAV = e^A$$

where:

-the Genus Mean Acute Value (GMAV) is the geometric mean of all species mean acute values (SMAVs) for each genus; the SMAV is the geometric mean of all EC_{50} and LC_{50} values for a species.

- the GMAVs are ranked (R) from "1" for the lowest to "N" for the highest; identical GMAVs are arbitrarily assigned successive ranks; and

- the cumulative probability (P) is calculated for each GMAV as R/(N+1)

Relative Potency Factor Calculations

The calculation of a "relative potency factor" (RPF) follows the recommendation of Felsot (2005). The purpose of determining an RPF is to normalize the relative potency (or toxicity) of two or more chemicals. In this case, the RPF is calculated to determine the relative toxicity of chlorpyrifos to diazinon. By multiplying the ambient diazinon concentration by the RPF, the diazinon concentrations are normalized to a concentration of chlorpyrifos that would be equivalent in terms of toxicity.

The RPF is expressed in terms of the "Final Acute Value" (FAV) and "Final Chronic Value" (FCV)[2]. The RPF based on the FAV is the Acute Relative Potency Factor (ARPF). The RPF based on the FCV is the Chronic Relative Potency Factor (CRPF).

Equation 1:

$$ARPF_{(chlorpyrifos/diazinon)} = \frac{FAV_{chlorpyrifos}\ (\mu g/L)}{FAV_{diazinon}\ (\mu g/L)}$$ (Acute Relative Potency Factor)

Equation 2:

$$CRPF_{(chlorpyrifos/diazinon)} = \frac{FCV_{chlorpyrifos}\ (\mu g/L)}{FCV_{diazinon}\ (\mu g/L)}$$ (Chronic Relative Potency Factor)

Equation 3:

FCV = FAV/ACR, where the ACR is the "acute to chronic" ratio.

Substituting equation 3 into equation 2 gives:

Equation 4:

$$CRPF_{(chlorpyrifos/diazinon)} = \frac{FAV_{chlorpyrifos} \times ACR_{diazinon}\ (\mu g/L)}{FAV_{diazinon} \times ACR_{chlorpyrifos}\ (\mu g/L)}$$

Substituting the values in Table 3 into equations 1 and 4, respectively, gives:

$$ARPF_{(chlorpyrifos/diazinon)} = \frac{0.0509\ (\mu g/L)}{0.3107\ (\mu g/L)} = 0.1638$$

$$CRPF_{(chlorpyrifos/diazinon)} = \frac{0.0509\ (\mu g/L) \times 3}{0.3107\ (\mu g/L) \times 3.5} = 0.1404$$

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[2] Note that although Felsot (2005) focused on the acute criteria or endpoints, the approach can also be applied to chronic criteria or endpoints.

Comparison of the "Toxic Equivalents" Calculation Method and the Basin Plan's "Toxic Units" Method for Considering Additive Toxicity

The section presents the two methodologies considered in establishing the loading capacity of the San Joaquin River for inputs of diazinon and chlorpyrifos. The "Toxic Equivalents" method [Equation 2] is shown to produce the same conclusion regarding attainment of applicable objectives as the "Toxic Units" method found in the Basin Plan [Equation 1].

The Basin Plan Toxic Units approach is:

$$\frac{C_{diazinon}}{O_{diazinon}} + \frac{C_{chlorpyrifos}}{O_{chlorpyrifos}} = S \leq 1 \quad \text{[Equation 1]}$$

$C_{diazinon}$ = ambient diazinon concentration
$C_{chlorpyrifos}$ = ambient chlorpyrifos concentration
$O_{diazinon}$ = diazinon water quality objective or criteria
$O_{chlorpyrifos}$ = chlorpyrifos water quality objective or criteria

The proposed Toxic Equivalents approach is:

$$\text{ChlorTEQ} = C_{diazinon} \times RPF_{(Chlorpyrifos/Diazinon)} + C_{chlorpyrifos} \leq O_{chlorpyrifos} \quad \text{[Equation 2]}$$

Where:

$$RPF_{(chlorpyrifos/diazinon)} = \frac{FAV_{chlorpyrifos}}{FAV_{diazinon}} \quad \text{[Equation 3]}$$

Multiplying both sides of Equation 1 by "$O_{chlorpyrifos}$" yields:

$$\frac{O_{chlorpyrifos}}{O_{diazinon}} \times C_{diazinon} + C_{chlorpyrifos} \leq O_{chlorpyrifos} \quad \text{[Equation 1a]}$$

Using the U.S. EPA methodology for deriving acute criteria:

$$O_{chlorpyrifos} = FAV_{chlorpyrifos} / 2 \quad \text{[Equation 4a]}$$
$$O_{diazinon} = FAV_{diazinon} / 2 \quad \text{[Equation 4b]}$$

Substituting equations 4a and 4b into the left hand side of Equation 1a gives:

$$\frac{FAV_{chlorpyrifos}}{FAV_{diazinon}} \times C_{diazinon} + C_{chlorpyrifos} \leq O_{chlorpyrifos} \quad \text{[Equation 1b]}$$

Substituting Equation 3 into Equation 1b gives:

$RPF_{(chlorpyrifos/diazinon)} \times C_{diazinon} + \underline{C_{chlorpyrifos}} \leq O_{chlorpyrifos}$ [Equation 1c]

Equation 1 (the Basin Plan "Toxic Units" approach) has been shown to be the same as Equation 2 (the "Toxic Equivalents" approach).