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SUBJECT: REVIEW OF THE U.S. ENVIRONMENTAL PROTECTION AGENCY AQUATIC LIFE BENCHMARKS, WITH MONITORING RECOMMENDATIONS

SUMMARY

The Department of Pesticide Regulation (DPR) conducts surface water monitoring for pesticide active ingredients (AIs) and degradates, and compiles pesticide surface water monitoring data from other outside sources. These monitoring data are used to assess the extent of surface water contamination and to estimate potential impacts such contamination may have on aquatic systems. These assessments are useful in subsequent project planning efforts and in DPR's regulatory decision-making process.

In some cases, monitoring results are compared to aquatic toxicity data in order to estimate the potential for impacts on aquatic organisms. Additionally, information on pesticide aquatic toxicity is useful for developing surface water monitoring priorities. The objective of this memorandum is to assess a suite of aquatic toxicity benchmarks (EPA benchmarks) recently compiled by the U.S. Environmental Protection Agency (EPA) Office of Pesticide Programs (OPPs) (U.S. EPA 2007) and to describe how these benchmarks can be utilized by DPR's Surface Water Protection Program.

BENCHMARK REVIEW

Water Quality Criteria

One method of assessing the potential impacts of pesticide contamination of surface water is by comparison of pesticide concentrations with National Ambient Water Quality Criteria (WQC) established to protect aquatic life. WQC are developed following methods developed by U.S. EPA; the method requires toxicity data representing a minimum of eight families of organisms. Vertebrate, invertebrate, and aquatic plant species are considered. Normally, both acute and chronic limits are developed (Marshack 2007). Since toxicity data for a variety of organism types are included in the development of WQC, they provide a broader overall toxicity measure than single species toxicity data. WQC exist for only a few of the many pesticide AIs registered for use in California. When no WQC exist, toxicity data from other sources may be

used to estimate impacts on aquatic organisms and interpret monitoring results. When WQC exist, their use is recommended over, or in addition to, any single species toxicity benchmarks or data.

Aquatic Benchmarks

U.S. EPA recently developed a Web site containing a summary of aquatic life benchmarks taken from pesticide-specific ecological risk assessments. These are single species benchmarks. Toxicity information for development of the benchmarks was drawn from OPP risk assessments, largely from the Reregistration Eligibility Decision documents. U.S. EPA OPP has indicated that additional benchmarks will be summarized and published periodically (U.S. EPA 2007).

Benchmarks for 71 pesticide AIs and degradates were included (Table A-1, Appendix A). Up to seven benchmarks were developed for each pesticide compound. Benchmark types include acute toxicity benchmarks for fish, invertebrates, and vascular and nonvascular plants and chronic toxicity benchmarks for fish, invertebrates, and aquatic community. In general, the benchmarks are the lowest toxicity value resulting from standardized tests, with a safety factor applied to the acute fish and invertebrate data. According to EPA, "the typical assessment endpoints… for pesticide ecological risk assessments are reduced survival and reproductive impairment…from both direct acute and direct chronic exposures. For aquatic plants, the assessment is concerned with maintenance and growth of standing crop or biomass. Measurement endpoints…focus on algal growth rates and biomass measurements as well as similar measurements for vascular plants" (U.S. EPA 2004). Specific test endpoints include mortality (acute fish/invertebrates) and such sublethal endpoints as fish larval length, young per adult, and reduced growth (chronic fish, acute plants). The benchmark types, standardized tests used, and additional information are shown in Table 1.

Environmental Protection Agency makes the following statements regarding the benchmarks:

"OPPs aquatic life benchmarks are derived from standardized tests that measure the toxicity of an individual pesticide or metabolite to fish, aquatic plants, or aquatic invertebrates. Comparing a measured concentration of a pesticide in water with an aquatic life benchmark provides an initial perspective on the relevance of the pesticide concentration to environmental health and can be used to identify and prioritize sites and pesticides that may require further investigation."

"Aquatic life benchmarks are estimates of the concentrations below which pesticides are not expected to have the potential for adverse effects on aquatic life. These benchmarks can be used as indicators of potential hazard to aquatic life, but they are not detailed toxicity and risk assessments. Concentrations of pesticides in streams…that exceed benchmarks indicate that further work needs to be done to gather more detailed information and…to characterize the likelihood of adverse effects on aquatic life" (U.S. EPA 2007).

These statements summarize the most salient points regarding the benchmarks and the appropriate uses for the data. Pesticide concentrations that exceed a benchmark are best considered to be indicators of a potential hazard to aquatic life. A single exceedance may not be indicative of an ongoing problem or a significant threat to aquatic organisms; however, consistent or frequent exceedances may indicate such a problem, and further investigation may be warranted.

Additionally, pesticides with high aquatic toxicity, as indicated by low toxicity benchmarks, may be reasonable candidates for inclusion in surface water monitoring efforts; additional information, including use patterns and available monitoring data, should also be considered in development of such monitoring priorities.

For DPR's purposes, the use of EPA benchmarks to interpret pesticide concentrations and to develop monitoring priorities is a reasonable application of the data. The significance of benchmark exceedances should be considered on a case-by-case basis. The nature of the benchmark (i.e., chronic versus acute) and the applicable test endpoint should also be taken into account (Table 1). When available, WQC should be considered in conjunction with EPA benchmarks. Additional toxicity information, if available, should also be considered when evaluating surface water monitoring data.

MONITORING RECOMMENDATIONS

U.S. EPA benchmarks were used in conjunction with recent pesticide use data (DPR 2007a) and surface water monitoring data (DPR 2007b, CVRWQCB 2007) to assess the 71 chemicals (68 AIs and 3 degradates). The primary goal of this assessment was to identify pesticides and pesticide degradates which have the potential to impact aquatic organisms and have not already been placed into reevaluation by DPR.

Both agricultural and nonagricultural pesticide use data were included in the assessment. These data were acquired through California's pesticide use reporting program (DPR 2008). The program requires reporting of both agricultural and nonagricultural pesticide applications, but does not include data for consumer product use. As such, consumer product use was not included in the development of monitoring recommendations. For many AIs, consumer product use is low or nonexistent; for others, use can be quite high. DPR is currently developing monitoring priorities for nonagricultural/urban use pesticides, including consumer products, in a separate project.

Additional details of the assessment are presented in Appendix A. In general, high toxicity (low benchmark values), high use (especially high wet season use) and recent detections increased the likelihood of an AI being recommended as a monitoring candidate or for further assessment. Toxicity information other than the EPA benchmarks was not considered in this assessment.

Monitoring Candidates

Of the 71 chemicals, 13 are newly recommended as monitoring candidates based on the benchmark assessment; the assessment also supports a previous monitoring recommendation for nine additional AIs (Table 2). The previous assessment (Starner 2007) considered the acute aquatic toxicity of pesticides to fish, crustaceans, aquatic insects, and zooplankton. Toxicity to aquatic plants, and chronic and sublethal effects in general, were not considered in that previous assessment. The benchmarks included in the current assessment do incorporate information on plant toxicity, as well as chronic and sublethal effects. All 13 of the newly recommended monitoring candidates are recommended based on chronic toxicity and/or toxicity to aquatic plants.

Information regarding regions of high use of the monitoring candidates, along with additional related information, is presented in Table 3. Additional assessment of information such as physiochemical properties and typical agricultural practices may be useful prior to initiation of monitoring. DPR is currently conducting or planning monitoring for several of the recommended AIs. Two AIs not included in the monitoring recommendation are permethrin and chlorpyrifos. These AIs are significantly toxic to aquatic organisms; their exclusion from the monitoring recommendation is due strictly to their regulatory status. The two (and several additional pyrethroid AIs) are currently under reevaulation by DPR, and monitoring for these AIs will be completed as a part of that process. Additionally, diazinon is in reevaluation for dormant spray uses; as such, monitoring recommendations here are for dry season uses and winter uses other than dormant spray applications.

No Current Monitoring Need

Forty-seven compounds are designated as having no current monitoring need in California based on the benchmark assessment.

Of these, 20 were included in one of two “Watch Lists” (Table 4). For these compounds, monitoring may be warranted if use patterns change or if new information on toxicity becomes available. Inclusion of an AI in a watch list was due to a combination of either high toxicity/low current use (Watch List 1) or high current use/low toxicity (Watch List 2). For Watch List 1, it is recommended that use data be reassessed at regular intervals to identify any significant increase in use that may indicate a need for monitoring. For Watch List 2, any new data on toxicity should be assessed to determine if monitoring for these AIs should be reconsidered. Additionally, for those AIs with high toxicity and low current use (Watch List 1), review of uses not considered in this assessment (unreported consumer product use) should be conducted to determine if monitoring may be warranted.

The remaining 27 chemicals have either low aquatic toxicity and low use in California (18 chemicals) or are not registered for use in California (9 chemicals) (Table 5), and as such are not recommended for monitoring. Monitoring/assessment by DPR of pesticides not registered for use in California is not appropriate, as DPR's regulatory authority extends only to those pesticides currently registered in California.

DPR surface water monitoring efforts will not be limited to the pesticides identified in this assessment. This assessment is intended to supplement a previous assessment described in Starner 2007. Additional efforts by DPR to identify monitoring candidates are anticipated.

Assessment Candidates

In addition to determining monitoring candidates, recommendations were developed regarding the need for more in-depth assessments of existing monitoring data. Such assessment is recommended for two AIs: diuron and thiobencarb. For these AIs, the preliminary assessment of existing monitoring data completed here indicates that exceedances of one or more EPA benchmarks occur frequently enough to warrant a more thorough assessment of recent monitoring data. One additional AI, diazinon, has also been recently identified as an assessment candidate, and a separate assessment of recent diazinon monitoring data is currently underway.

REFERENCES

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U.S. EPA 2007. Aquatic Life Benchmarks for Pesticides. Available at: <http://www.epa.gov/oppfead1/cb/csb_page/updates/2007/aquatic-life.htm>.

Table 1. Aquatic Toxicity Benchmark Information

Benchmark type	Toxicity value	LOC	Usual test organism	Test endpoints (2)
Acute fish	lowest 96-h LC50	0.5	rainbow trout, fathead minnow or bluegill	mortality
Chronic fish	lowest NOAEC, life-cycle or early life stage	1	rainbow trout or fathead minnow	larval fish length or weight
Acute invertebrates	lowest 48- or 96- hour EC50 or LC50	0.5	midge, scud, or daphnids	mortality
Chronic invertebrates	lowest NOAEC, life cycle test	1	midge, scud, or daphnids	survival, growth, young/adult
Acute nonvascular plant	short-term (<10 days) EC50	1	green algae or diatoms	reduction in growth
Acute vascular plant	short-term (< 10 days) EC50	1	duckweed	reduction in growth
Chronic aquatic community	(1)	NA	NA	(1)

(1) Exceedance of this benchmark concentration, as an average for any 60-day period,
could cause community-level effects based on changes in plant community diversity and indirect effects on fish and aquatic invertebrates.
NA = not available
(2) A partial list of endpoints.

Benchmark = Toxicity value X LOC (Level of concern).
EC50 = 50 percent effect concentration
LC50 = 50 percent lethal concentration
LOC = level of concern
NOAEC = no observed adverse effects concentration

Table 2. Results of EPA Benchmark assessment: Monitoring candidates

Chemical	Classification	Annual Use	Wet Season Use	Lowest Benchmarks (ug/L)	Monitoring summary (4)	Note
Oxyfluorfen	diphenyl ether herbicide	very high	high	0.29 acute nonvasc plants	Few samples	1
Aldicarb	carbamate insecticide	high	none	0.46 chronic fish, 1.0 chronic inverts	Few samples	1
Disulfoton	OP insecticide	low	very low	0.037 chronic / 1.95 acute inverts	Few detections	1
Ethoprop	OP insecticide	low	very low	0.8 chronic inverts	Few samples	1
Ethalfluralin	dinitroaniline herbicide	low	very low	0.4 chronic fish	Few samples	1
Diuron	urea herbicide	very high	very high	2.4 acute nonvasc plants	Detection freq > 30%; 5% exceedances	1
Pendimethalin	dinitroaniline herbicide	very high	high	6.3 chronic fish, 5.4 acute nonvasc plants	Detection freq > 15%; no exceedances	1
Propargite	insecticide	very high	very low	9.0 chronic inverts	Detection freq ca 15%; no exceedances	1
Propanil	anilide herbicide	very high	none	9.1 chronic fish; 16.0 nonvasc plants	Detection freq ca 20%; few exceedances	1
Tribufos	OP defoliant	high	very low	2.0 chronic inverts	Few samples	1
Thiobencarb	thiocarbamate herbicide	high	none	1.0 chronic inverts	Detection freq > 30%; 15% exceedances	1
Simazine	triazine herbicide	very high	high	36 acute nonvasc plants	Detection freq > 35%; winter detect freq > 60%	1
Oryzalin	dinitroaniline herbicide	very high	high	15.4 acute vasc plants	Few samples	1
Diazinon	OP insecticide	high	high	0.1 acute / 0.17 chronic inverts	Detection freq ca 35%; 10% exceedances	2
Malathion	OP insecticide	high	moderate	0.06 chronic / 0.25 acute inverts	Some detections, few exceedances	2
Methomyl	carbamate insecticide	high	low	0.4 chronic inverts	Some detections, few exceedances	2
Methyl Parathion	OP insecticide	moderate	very low	0.02 chronic / 0.07 acute inverts	Few detections	2
Phorate	OP insecticide	low	very low	0.21chronic/0.3 acute inverts;0.5 acute fish	Few detections	2
Trifluralin	dinitroaniline herbicide	very high	high	1.14 chronic fish	Detection freq ca 20%	2
Chlorothalonil	fungicide	very high	moderate	3.0 chronic fish	Few samples	2
Carbaryl	carbamate insecticide	high	very low	1.5 chronic / 2.55 acute inverts	Some detections, no exceedances	2
Dimethoate	OP insecticide	high	low	21.5 acute inverts	Detection freq ca 10%; no exceedances	2
Chlorpyrifos	OP insecticide	very high	high	0.04 chronic / 0.05 acute inverts	Undergoing DPR Reevaluation	3
cis-Permethrin	pyrethroid insecticide	very high	moderate	0.039 chronic / 0.0195 acute inverts	Undergoing DPR Reevaluation	3

Notes: 1= Monitoring candidate; 2 = Monitoring candidate, previously recommended (Starner 2007); 3 = Undergoing DPR reevaluation
Note 4: All monitoring data from DPR 2007b.
Exceedance = sample with detected concentration greater than a toxicity benchmark
Monitoring data analysis: further assessment of diuron and thiobencarb recommended; assessment of diazinon monitoring data underway by DPR.

Table 3. Results of Benchmark Assessment: High use regions for monitoring candidates

Active Ingredient	Code	Analytical Method	High use regions/seasons	Note
Oxyfluorfen	1973	Dinitroaniline screen	winter, various regions, AG	Current targeted monitoring ongoing.
Aldicarb	575	Carbamate screen	spring/summer, N and SSJV, AG	
Disulfoton	230	OP screen	Fall, NSJV, AG	
Ethoprop	404	OP screen	spring. NSJV, AG	
Ethalfluralin	2166	Dinitroaniline screen	spring/summer, Sac V. AG	
Diuron	231	Triazine/herb screen	various seasons and regions, AG and NONAG	Analysis of recent monitoring data recommended
Tribufos	190	OP screen	Fall, NSJV and SSJV, AG	
Pendimethalin	1929	Dinitroaniline screen	various seasons and regions, AG and NONAG	
Propargite	445		summer, Sac, NSJV, SSJV AG; spring SSJV	
Propanil	503		spring/summer, Sac V., AG (very high use);	
Thiobencarb	1933	stand alone	spring/summer, Sac V. AG	Analysis of recent monitoring data recommended
Simazine	531	Triazine/herb screen	winter, various regions mostly AG; other seasons also	
Oryzalin	1868	Dinitroaniline screen	fall/winter, various regions, AG	
Diazinon	198	OP screen	spring/summer C. Coast, fall SE Interior, AG	Note 1. Analysis of recent monitoring data underway.
Malathion	367	OP screen	various, AG/NONAG	Note 1. Current targeted monitoring ongoing.
Methomyl	383	Carbamate screen	various, AG/NONAG	Note 1. Current targeted monitoring ongoing.
Methyl Parathion	394	OP screen	summer NSJV, Sac V, AG	Note 1.
Phorate	478	OP screen	NSJV, Sac V, SE Interior, spring, AG	Note 1.
Trifluralin	597	Dinitroaniline screen	NSJV, SE Interior winter/spring AG	Note 1. Current targeted monitoring ongoing.
Chlorothalonil	677		summer NSJV, various S Coast, AG	Note 1.
Carbaryl	105	Carbamate screen	spring/summer, NSJV	Note 1.
Dimethoate	216	OP screen	various, AG	Note 1.

All use data is from DPR 2007.
(1) Monitoring previously recommended; see Starner 2007.
AG = Agricultural use; NONAG = nonagricultural use
NSJV = North San Joaquin Valley, primarily San Joaquin, Stanislaus, and Merced counties
SSJV = Southern San Joaquin Valley, primarily Fresno, Madera, Kings, Tulare, and Kern
Sac V = Sacramento Valley, primarily Sutter, Yolo, Colusa, Butte, and Glenn counties
SE Interior = Inland southeast, primarily Imperial, and Riverside counties
C Coast = Santa Cruz, Monterey, San Benito, and San Luis Obispo counties.
S Coast = Los Angeles, Orange, Santa Barbara, and Ventura counties

Table 4. Results of Benchmark Assessment: Watch Lists

Watch List	Chemical	Classification	Annual Use	Wet Season Use	Lowest Benchmarks (ug/L)	Monitoring summary
1	Ethyl Parathion	OP insecticide	very low	very low	0.002 chronic / 0.02 acute inverts	no detections
1	Methiocarb	carbamate insecticide	very low	very low	0.10 chronic / 3.5 acute inverts	no detections
1	Profenophos	OP insecticide	very low	none	0.20 chronic / 0.45 acute inverts	no detections
1	Alachlor	chloroacetanilide herbicide	low	very low	1.64 acute nonvasc plants	few detections, no exceeds
1	Benfluralin	dinitroaniline herbicide	low	very low	1.9 chronic fish	few detections, no exceeds
1	Propoxur	carbamate insecticide	very low	very low	5.5 acute inverts	few samples, no exceeds
1	Bromacil	uracil herbicide	low	low	6.8 acute nonvasc plants	Few samples, some detections
1	Metribuzin	triazine herbicide	low	very low	8.7 acute nonvasc plants	Detection freq ca 5%, no exceeds
1	Norflurazon	pyridazinone herbicide	moderate	moderate	13.0 acute nonvasc plants	Few samples, some detections
1	Atrazine	triazine herbicide	low	very low	18.0 acute vasc plants	Detection freq ca 10%, no exceeds
1	Carbofuran	carbamate insecticide	low	very low	0.75 chronic/1.115 acute inverts	Undergoing phase-out, USEPA
1	Azinphos methyl	OP insecticide	moderate	very low	0.08 acute/ 0.16 chronic inverts	Undergoing phase-out, USEPA
2	Molinate	thiocarbamate herbicide	high	none	all > 60	Detection freq ca 18%; no exceeds
2	Methyl bromide	fumigant	very high	high	all > 60	no monitoring data
2	Glyphosate	phosphonoglycine herbicide	high	low	all > 60	few detections; no exceeds
2	Dacthal	alkylphthalate herbicide	high	low	all > 60	Detection freq ca 8%; no exceeds
2	Pronamide	amide herbicide	high	low	all > 60	few detections; no exceeds
2	EPTC	thiocarbamate herbicide	high	low	all > 60	Detection freq ca 30%; no exceeds
2	Oxamyl	carbamate insecticide	high	very low	all > 60	few detections; no exceeds
2	Metolachlor	chloroacetanilide herbicide	high	very low	all > 60	Detection freq ca 20%; no exceeds

Watch list 1: Low current use / high toxicity.
Use data should be reassessed at regular intervals to identify any significant increase in use that may indicate a need for monitoring.

Watch list 2: High current use / low toxicity.
Any new data on toxicity or potential impacts on aquatic organisms should be reviewed to determine if monitoring should be conducted.

Table 5. Results of Benchmark Assessment: No current monitoring need

Chemical	Classification	Annual Use	Wet Season Use	Lowest Benchmarks (ug/L)	Monitoring summary
Triallate	thiocarbamate herbicide	none	none	13.0 chronic inverts	no monitoring data
MCPA	chlorophenoxy herbicide	very low	very low	20.0 acute vasc plants	few samples, no exceeds
Aldicarb sulfoxide	degradate of aldicarb	parent: high	parent: none	21.5 acute inverts	few samples, no detections
Dichlobenil	substituted benzene herbicide	low	very low	30.0 acute vasc plants	few samples, no detections
Linuron	urea herbicide	moderate	very low	42.0 chronic fish	few detections; no exceeds
Tebuthiuron	urea herbicide	very low	very low	50.0 acute nonvasc plants	few detections, no exceeds
2,4-DB	chlorophenoxy herbicide	very low	none	all > 60	no monitoring data
Acifluorfen	diphenyl ether herbicide	none	none	all > 60	no monitoring data
Pebulate	thiocarbamate herbicide	very low	none	all > 60	few detections, no exceeds.
MCPB	chlorophenoxy herbicide	none	none	all > 60	few samples, no exceeds
Butylate	thiocarbamate herbicide	very low	none	all > 60	few detections; no exceeds.
Propiconazole	azole fungicide	low	very low	all > 60	few samples, no exceeds
Napropamide	amide herbicide	low	very low	all > 60	Detection freq ca 8%; no exceeds.
Cycloate	thiocarbamate herbicide	low	very low	all > 60	few samples, no exceeds
Dicamba	benzoic acid herbicide	very low	very low	all > 60	few samples, no exceeds
2,4-D	chlorophenoxy herbicide	very low	very low	all > 60	few samples, no exceeds
Picloram	pyridinecarboxylic acid herbicide	none	none	all > 60	few samples, no exceeds
Aldicarb sulfone	degradate of aldicarb	parent: high	parent: none	all > 60	few samples, no detections
Terbufos	OP insecticide	not Calif. Registered		0.03 chronic / 0.1 acute inverts	not reviewed
gamma-HCH	lindane degradate	not Calif. Registered		0.5 acute inverts; 0.85 acute fish	not reviewed
Lindane	organochlorine insecticide	not Calif. Registered		see degradate	not reviewed
Ametryn	triazine herbicide	not Calif. Registered		3.67 acute nonvasc plants	not reviewed
Terbacil	uracil herbicide	not Calif. Registered		11.0 acute nonvasc plants	not reviewed
Propachlor	Chloroacetanilide herbicide	not Calif. Registered		13.5 acute nonvasc plants	not reviewed
Fluometuron	Urea herbicide	not Calif. Registered		30 acute nonvasc plants	not reviewed
Bentazon	herbicide	not Calif. Registered		all > 60	not reviewed

Appendix A

Use assessment:

Pesticide use information and ranks presented in Tables 2 through 5 are based on the combined reported agricultural and nonagricultural use for 2005 (DPR 2007a). Ranks are for comparison within categories; the same ranking scheme was used for Winter Use and Annual Use ranks. For Annual Use, rank was also determined using three-year average of use with similar results. Winter Use is defined as use during the months of December through February, when most rainfall occurs in California.

Pounds AI	Rank
< 15,000	very low
15,000 to 49,999	low
50,000 to 99,999	moderate
100,000 to 499,999	high
≥ 500,000	very high

Assessment of monitoring data:

The assessment of recent monitoring data completed for this report used all recent monitoring data from DPR's surface water database (2000-2006), as well as all available CVRWQCB Irrigated Lands Regulatory Program monitoring data (2004 through 2006).

The Irrigated Lands monitoring data can be accessed at: <http://www.swrcb.ca.gov/rwqcb5/water_issues/irrigated_lands/monitoring_activity/index.html>.

Table A-1. U.S. EPA Aquatic Life Benchmarks (ug/L) for Pesticides

AI (OPP Name)	Acute fish (all in ug/L)	Chronic fish	Acute invertebrates	Chronic invertebrates	Acute nonvascular plants	Acute vascular plants	Chronic aquatic community
2,4-D	50500	14200	12500	16400	3880	299.2	—
2,4-DB	1000	—	7500	—	932	—	—
Acifluorfen	15500	1500	14050	—	265000	378000	—
Alachlor	900	187	1600	110	1.64	—	—
Aldicarb	26	0.46	10	1	50000	—	—
Aldicarb sulfone	21000	—	140	—	—	—	—
Aldicarb sulfoxide	3570	—	21.5	—	—	—	—
Ametryn	1800	700	14000	240	3.67	10	
Atrazine	2650	62	360	62	32	18	17.5
Azinphos-methyl	0.18	0.36	0.08	0.16	—	—	—
Benfluralin	15.85	1.9	1090	15.5	100	—	—
Bentazon	50000	—	50000	—	4500	5350	—
Bromacil	18000	—	60500	—	6.8	—	—
Bromoxynil	11.5	9	5.5	2.5	51	219	—
Butylate	105	210	5950	—	—	—	—
Carbaryl	125	210	2.55	1.5	1100	—	—
Carbofuran	44	5.7	1.115	0.75	—	—	—
Chlorothalonil	11.5	3	34	39	190	—	—
Chlorpyrifos	0.9	0.57	0.05	0.04	140	—	—
cis-Permethrin	0.395	0.3	0.0195	0.039	—	—	—
Cycloate	2250	—	1300	—	—	—	
Dacthal	15000	—	13500	—	11000	11000	—
Diazinon	45	0.55	0.1	0.17	3700	—	—
Dicamba	14000	—	17300	—	61	> 3,250	—

<http://www.epa.gov/oppfead1/cb/csb_page/updates/2007/aquatic-life.htm>.

Table A-1. US EPA Aquatic Life Benchmarks (ug/L) for Pesticides

AI (OPP Name)	Acute fish (all in ug/L)	Chronic fish	Acute invertebrates	Chronic invertebrates	Acute nonvascular plants	Acute vascular plants	Chronic Aquatic community
Dichlobenil	2465	330	1850	560	1000	30	—
Dimethoate	3000	430	21.5	40	—	—	—
Disulfoton	19.5	39	1.95	0.037	—	—	—
Diuron	355	26	80	160	2.4	—	—
EPTC	7000	—	3250	—	1360	5600	—
Ethalfluralin	16	0.4	30	24	25	—	—
Ethoprop	150	24	22	0.8	8400	—	—
Fluometuron	320	—	110	—	30	220	—
gamma-HCH	0.85	1.7	0.5	1	—	—	—
Glyphosate	42450	> 25,700	27500	> 50,000	850	21500	—
Linuron	1500	42	60	120	67	—	—
Malathion	2	4	0.25	0.06	—	—	—
MCPA	380	12000	90	11000	160	20	—
MCPB	1950	—	25000	—	380	210	—
Methiocarb	218	50	3.5	0.1	—	—	—
Methomyl	265	57	4.4	0.4	—	—	—
Methyl bromide	1950	100	1300	—	—	—	
Metolachlor	1950	780	12550	—	—	—	—
Metribuzin	21000	3000	2100	1290	8.7	130	—
Molinate	105	210	170	340	220	3300	—
Napropamide	3200	—	7150	—	3400	—	—
Norflurazon	4050	770	7500	1000	13	86	—
Oryzalin	1440	220	700	—	42	15.4	—
Oxamyl	2100	770	90	180	—	—	—

<http://www.epa.gov/oppfead1/cb/csb_page/updates/2007/aquatic-life.htm>.

Table A-1. U.S. EPA Aquatic Life Benchmarks (ug/L) for Pesticides

AI (OPP Name)	Acute fish (all in ug/L)	Chronic fish	Acute invertebrates	Chronic invertebrates	Acute nonvascular plants	Acute vascular plants	Chronic aquatic community
Oxyfluorfen	100	38	40	13	0.29	—	—
Parathion	9	0.19	0.02	0.002	—	—	—
Parathion-methyl	500	80	0.07	0.02	5300	—	—
Pebulate	3150	—	3315	—	230	1800	—
Pendimethalin	69	6.3	140	14.5	5.4	12.5	—
Phorate	0.5	1	0.3	0.21	1300	—	—
Picloram	6500	550	34150	11800	4900	—	—
Profenophos	12.5	2	0.45	0.2	—	—	—
Pronamide	36000	—	2800	—	760	—	—
Propachlor	85	—	395	—	13.5	—	—
Propanil	1150	9.1	600	86	16	110	—
Propargite	15.5	16	37	9	19.4	75000	—
Propiconazole	425	95	2400	205	93	4828	—
Propoxur	1850	—	5.5	—	—	—	—
Simazine	3200	960	500	1000	36	140	—
Tebuthiuron	53000	9300	148500	21800	50	135	—
Terbacil	23100	—	31500	—	11	140	—
Terbufos	0.385	0.77	0.1	0.03	—	—	—
Thiobencarb	280	—	50	1	17	770	—
Triallate	600	38	45.5	13	120	—	—
Tribufos	122.5	—	13.5	2	148	—	—
Trifluralin	20.5	1.14	280	2.4	7.52	43.5	—

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