

U.S. Environmental Protection Agency

Revised OP (Organophosphate)
Cumulative Risk Assessment

June 10, 2002

III. Appendices

E. Water Exposure Assessment (sections 1-6)

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III. Appendices

E. Water Appendix

1. Comparisons of Estimated Regional OP Pesticide Distributions with Occurrences in Ambient Waters from the USGS NAWQA Program

OPP conducted refined surface water modeling to estimate potential OP cumulative exposure in drinking water. These estimates represent combined OP concentrations in untreated surface water sources of drinking water. As a part of its evaluation, OPP compared estimated OP concentrations in water to available surface water monitoring data. The most extensive source of monitoring data for multiple pesticides is the USGS NAWQA program. NAWQA included nine OP pesticides that are part of the OP cumulative risk assessment: azinphos-methyl, chlorpyrifos, diazinon, disulfoton, ethoprop, malathion, methyl parathion, phorate, and terbufos. Not every OP was included in each regional assessment, which represents a drinking water source that is potentially vulnerable to cumulative OP impacts. Only chlorpyrifos was included in each of the regional assessments. Similarly, only those OP pesticides used in the vicinity of monitoring stations have the potential to be found in each of the NAWQA study units.

While comparisons of the estimated concentrations with ambient water monitoring are valuable in evaluating and characterizing the OP cumulative drinking water exposure assessment, certain limitations need to be acknowledged:

- ☐ This is not a comparison of the same water bodies. The estimated cumulative OP concentrations used in the regional exposure assessments represent concentrations that would occur in a reservoir, and not in the streams and rivers represented by the NAWQA sampling.
- ☐ The sampling frequency of the NAWQA study (sample intervals of 1 to 2 weeks apart or less frequent) was not designed to capture peak concentrations, so it is unlikely that the monitoring data will include true peak concentrations. This may be particularly critical for pesticides such as phorate or terbufos, where the estimated pulse load of the parent is of a relatively short duration.
- ☐ The estimated concentration profile represents a wide distribution of weather patterns (19 to 35 years), while the NAWQA data reflect a smaller time window (generally up to 3 years). Thus, the estimated profile may better characterize the year-to-year fluctuations in weather patterns than is seen in the shorter time frame of the NAWQA study.
- ☐ Several regionally-significant OP pesticides were not included in the NAWQA study, so direct comparisons are not possible. Several significant

transformation products, in particular the sulfone and sulfoxide products of disulfoton, phorate, and terbufos, were also not included in NAWQA.

- The NAWQA study did not focus on drinking water, and monitoring reflect a range of ambient waters. OPP tried to focus on those sampling sites that fed into drinking water sources or were reflective of drinking water sources in the region.

The significance of detections or non-detections in the monitoring data depends partially on the persistence and activity of the parent compound versus the metabolites. Given the frequency of sampling, NAWQA is more likely to detect a persistent OP pesticide than a nonpersistent one if they are indeed present in water. Relatively persistent and active OP compounds in the NAWQA tored in NAWQA include diazinon, chlorpyrifos, ethoprop, and azinphos methyl. Diazinon and chlorpyrifos, also with the most widespread use, were the most frequently detected compounds. Malathion is not considered to be persistent but was observed frequently. It is used as an aduIticide and was detected most frequently in mixed and urban areas.

However, compounds such as phorate, terbufos, and disulfoton have generally non-persistent parent compounds, and rapidly form persistent and toxic sulfoxide and sulfone metabolites. The NAWQA data analyzed do not contain analyses for sulfoxide and sulfone metabolites, and there were generally few or no detections of the parent compounds. As illustrated in Region A, the likely short pulse of the parent phorate may be missed in bi-weekly sampling. It is possible that exposure to total toxic residues (parent + sulfoxide + sulfone) is likely underestimated. Similarly, a non-detection of a parent compound may not signify that toxic residues of a particular pesticide are not present in a sample. Consequently, exposure to total toxic residues is also likely to be underestimated.

This appendix is divided into seven sections – one for each of the regions in the OP cumulative risk assessment. Each of those regional sections are divided into two parts. The first part provides a comparison of the estimated concentration distributions for the OP pesticides included in the exposure assessment. The second part summarizes the USGS National Water Quality Assessment (NAWQA) program study units found in the regions.

a. Region A: Florida

The major contributor to the estimated OP cumulative exposure in this region was phorate use on sugarcane. Minor contributions came from phorate use on corn and ethoprop use on sugarcane. Table III.E.1-1 summarizes the estimated distribution profile for OP pesticide included in the exposure assessment. More detailed discussion and analysis of the OP load in drinking water sources can be found in section II.A.

Table III.E.1-1. Predicted percentile concentrations of individual OP pesticides and of the cumulative OP distribution in the Florida Region.

Chemical	Crop/Use	Concentration in ug/L (ppb)						
		Max	99th	95th	90th	80th	75th	50th
Acephate	Peppers	7.7e-02	6.8e-03	8.5e-04	2.8e-04	8.7e-05	5.7e-05	4.3e-06
Chlorpyrifos	Corn, Citrus	2.0e-01	9.6e-02	4.9e-02	3.3e-02	2.1e-02*	1.8e-02	9.1e-03
Diazinon	Lettuce, Tomato	2.9e-02	1.5e-02	9.1e-03	6.4e-03	4.0e-03	3.3e-03	1.1e-03
Ethoprop	Sugarcane	1.5e+00	5.1e-01	2.5e-01	1.7e-01	9.8e-02	8.0e-02	3.8e-02
Methamidophos	Peppers, Tomato	9.3e-03	1.7e-03	2.6e-04	8.4e-05	1.6e-05	9.9e-06	1.8e-07
Phorate(ttl)	Corn, Sugarcane	1.2e+01	7.2e-01	1.8e-02	1.1e-04	5.4e-09	8.5e-11	4.4e-12
OP Cumulative (in Methamidophos Equivalents, ppb)		1.4e+01	9.0e-01	7.8e-02	3.6e-02	2.0e-02	1.7e-02	8.1e-03

i. Comparison of Monitoring Data versus Model Estimates

The South Florida (SOFL) NAWQA study unit includes the vulnerable drinking-watersheds of the Florida Region. The estimated concentrations of chlorpyrifos were similar to the detections reported from agricultural sampling stations, with 80th percentile and greater estimated concentrations 5 to 8 times greater than similar percentiles of reported detections. Estimated 99th percentile concentrations for diazinon were similar to that measured in the SOFL unit. No comparisons could be made at lower percentiles, which extended beyond the frequencies of detection for these chemicals. While 90th and 95th percentile estimates for ethoprop were 20 to 30 times greater than similar percentiles from the SOFL unit, 99th and maximum estimates were closer (6 to 7 times greater). The study reported no detections of the parent phorate. While the estimated 99th percentile concentration of total phorate residues (including sulfone and sulfoxide) was more than two orders of magnitude greater than the limit of detection (LOD) for phorate, the LOD fell between the 90th and 95th percentile of the estimated distribution.

Figure III.E.1-1 compares the estimated percentile concentrations for ethoprop with the monitoring percentiles from the Hillsboro Canal at S-6 near Shawano. The estimated and observed levels of ethoprop in the Hillsboro Canal were similar with the exception of the maximum concentrations.

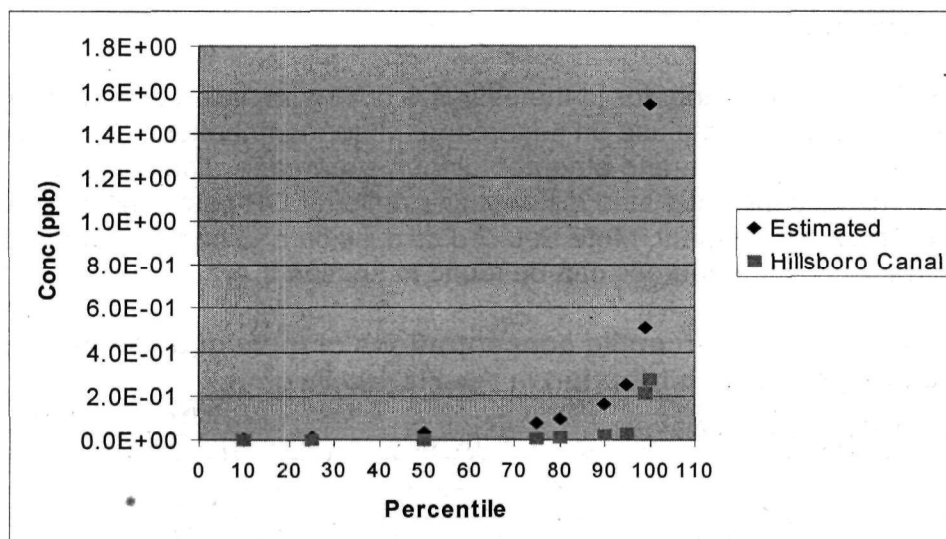


Figure III.E.1-1. Comparison of observed and estimated ethoprop concentrations in the Florida Region.

ii. Summary of NAWQA Monitoring Data in the Region

The **Southern Florida (SOFL) NAWQA** study unit includes the Biscayne aquifer, the Everglades, and portions of the Flatwoods and highly vulnerable Central Ridge regions of Florida. The Floridan, surficial and intermediate aquifers are also important sources of drinking water in this study unit. Ground water supplied 94% of water used in the study unit in 1990 (USGS Circular 1207).

Intensive surface water sampling in the SOFL study unit included canals draining mixed use (vegetables), citrus and sugar cane fields. Diazinon and chlorpyrifos were detected at low concentrations in the mixed use canal. Chlorpyrifos(max 0.023ug/l) and malathion (max 0.084 µg/l) were detected in 25% and 20% of samples from the citrus canal, with fewer detections of azinphos-methyl, methyl-parathion and ethoprop. Ethoprop was extensively (32%) detected in the sugarcane canal, with a maximum concentration of 0.279 µg/l. Chlorpyrifos, methyl parathion, diazinon and malathion were detected less frequently, and at lower concentrations. Sugarcane is the most important use for ethoprop. Although the sugarcane canal is not used for drinking water, this targeted monitoring indicates transport of ethoprop from the fields can be expected to occur.

The **Georgia-Florida Coastal Plain (GAFL) NAWQA** study unit extends from central Florida south of Tampa to just north of Atlanta, Georgia. The USGS reports that 80% of the population in this area derives its drinking water from ground water, and that 94% of that ground water is drawn from the Upper Floridan aquifer. About 25% of this region is devoted to agriculture,

and more than half to forestry. Most of the Georgia portion of the study unit is located within the Coastal Inlands Farm resource Region.

Surface-water monitoring in the GAFL study unit were located in Georgia, outside of the Fruitful Rim, SE Farm resource Region. Sampling in Florida included intensive sampling from an urban stream in Tallahassee, and a number of fixed stream-sampling stations. Diazinon and chlorpyrifos were detected frequently (54% and 45%) in urban and mixed land-use samples. Malathion was detected in 35% of urban stream samples, but not in mixed land-use samples, with a maximum concentration of 0.2 µg/l. Ethoprop, phorate, azinphos-methyl and diazinon were detected in 3 or fewer agricultural samples each, at concentrations <0.1 µg/l.

Table III.E.1-2. Magnitude and Frequency of Occurrence of OP Pesticides Analyzed in the NAWQA Study Units Found in the Florida Region.

Land Use	Value	chlorpyrifos	diazinon	disulfoton	ethoprop	malathion	azinphos-methyl	methyl parathion	phorate	terbufos
Concentration (ug/L)										
Southern Florida										
All Locations	Maximum	0.023	0.014	0.021	0.279	0.084	0.070	0.060	0.011	0.017
	99th	0.012	0.005	0.021	0.075	0.027	0.050	0.022	0.011	0.017
	95th	0.006	0.002	0.017	0.012	0.026	0.035	0.006	0.002	0.013
	90th	0.005	0.002	0.017	0.005	0.005	0.001	0.006	0.002	0.013
	80th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	14.7%	2.0%	0.0%	10.0%	8.0%	1.6%	2.0%	0.0%	0.0%
Agricultural	Maximum	0.023	0.005	0.021	0.279	0.084	0.070	0.060	0.011	0.017
	99th	0.012	0.005	0.021	0.094	0.027	0.050	0.023	0.011	0.017
	95th	0.006	0.002	0.017	0.014	0.025	0.025	0.006	0.002	0.013
	90th	0.005	0.002	0.017	0.005	0.005	0.001	0.006	0.002	0.013
	80th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	14.5%	0.0%	0.0%	9.0%	8.1%	1.4%	1.8%	0.0%	0.0%
Reference	Maximum	0.004	0.002	0.017	0.003	0.015	0.0421	0.006	0.002	0.013
	99th	0.004	0.002	0.017	0.003	0.0132	0.03470 2	0.006	0.002	0.013
	95th	0.004	0.002	0.017	0.003	0.006	0.00511	0.006	0.002	0.013
	90th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	80th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	0.0%	0.0%	0.0%	0.0%	5.3%	5.3%	0.0%	0.0%	0.0%
Mixed	Maximum	0.005	0.014	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	99th	0.005	0.014	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	95th	0.005	0.013	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	90th	0.004	0.013	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	80th	0.004	0.005	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.004	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	9.1%	27.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Canal-C111 (Ag)	Maximum	0.023	0.005	0.021	0.005	0.084	0.070	0.040	0.011	0.017
	99th	0.014	0.005	0.021	0.005	0.073	0.053	0.026	0.011	0.017
	95th	0.008	0.005	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	90th	0.006	0.002	0.017	0.003	0.026	0.029	0.006	0.002	0.013
	80th	0.005	0.002	0.017	0.003	0.006	0.001	0.006	0.002	0.013
	75th	0.005	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013

Land Use	Value	chlorpyrifos	diazinon	disulfoton	ethoprop	malathion	azinphos methyl	methyl parathion	phorate	terbufos
Concentration (ug/L)										
	Frequency	25.6%	0.0%	0.0%	1.2%	19.8%	3.5%	2.3%	0.0%	0.0%
Hillsboro Canal (Ag)	Maximum	0.007	0.005	0.021	0.279	0.027	0.050	0.060	0.011	0.017
	99th	0.006	0.003	0.018	0.215	0.011	0.050	0.024	0.004	0.014
	95th	0.004	0.002	0.017	0.033	0.005	0.001	0.006	0.002	0.013
	90th	0.004	0.002	0.017	0.024	0.005	0.001	0.006	0.002	0.013
	80th	0.004	0.002	0.017	0.011	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.009	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	10.8%	1.4%	0.0%	32.4%	1.4%	0.0%	4.1%	0.0%	0.0%
US Sugar Outflow (Ag)	Maximum	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	99th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	95th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	90th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	80th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Florida Portion of GA-FL Coastal Plain										
All Locations	Maximum	0.028	0.276	0.060	0.073	0.204	0.054	0.035	0.031	0.013
	99th	0.024	0.244	0.019	0.012	0.086	0.051	0.035	0.016	0.013
	95th	0.016	0.101	0.017	0.005	0.020	0.001	0.006	0.002	0.013
	90th	0.011	0.084	0.017	0.003	0.012	0.001	0.006	0.002	0.013
	80th	0.008	0.058	0.017	0.003	0.006	0.001	0.006	0.002	0.013
	75th	0.006	0.051	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.008	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	45.1%	54.2%	0.0%	3.5%	18.8%	2.1%	0.0%	1.4%	0.0%
Urban/ Residential	Maximum	0.028	0.276	0.017	0.007	0.204	0.001	0.006	0.002	0.013
	99th	0.0265	0.27375	0.017	0.0055	0.117	0.001	0.006	0.002	0.013
	95th	0.01725	0.16325	0.017	0.003	0.0364	0.001	0.006	0.002	0.013
	90th	0.0155	0.1005	0.017	0.003	0.02	0.001	0.006	0.002	0.013
	80th	0.011	0.081	0.017	0.003	0.011	0.001	0.006	0.002	0.013
	75th	0.01	0.07275	0.017	0.003	0.009	0.001	0.006	0.002	0.013
	50th	0.004	0.0445	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	52.6%	92.1%	0.0%	2.6%	35.5%	0.0%	0.0%	0.0%	0.0%
Mixed	Maximum	0.006	0.083	0.017	0.073	0.005	0.001	0.006	0.031	0.013
	99th	0.006	0.076	0.017	0.044	0.005	0.001	0.006	0.022	0.013
	95th	0.005	0.038	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	90th	0.005	0.004	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	80th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	56.8%	15.9%	0.0%	6.8%	0.0%	0.0%	0.0%	4.5%	0.0%

b. Region B: Northwest

Ethoprop had the highest estimated concentrations in the region (Table III.E.1-3), while dimethoate, azinphos methyl, and chlorpyrifos also contributed to the estimated peak OP cumulative load. More detailed discussion and analysis of the OP load in drinking water sources can be found in section II.B.

Table III.E.1-3. Estimated percentile concentrations of individual OP pesticides and of the cumulative OP distribution in the Northwest Region.

Chemical	Crop/Use	Concentration in $\mu\text{g/L}$ (ppb)						
		Max	99th	95th	90th	80th	75th	50th
Acephate	Cauliflower, nursery, mint	5.0e-04	3.6e-04	1.9e-04	7.8e-05	9.8e-06	4.4e-06	1.7e-08
Azinphos Methyl	Apples, pears, cherries, blackberry	7.5e-03	2.2e-03	9.8e-04	6.7e-04	4.1e-04	3.6e-04	2.1e-04
Bensulide	Broccoli, cabbage, cucumbers	4.0e-02	3.2e-02	2.5e-02	2.2e-02	1.8e-02	1.7e-02	1.3e-02
Chlorpyrifos	Fruit/nut trees, cole crops, onions, corn, grass, trees, mint	6.0e-02	2.7e-02	1.6e-02	1.3e-02	9.8e-03	8.8e-03	5.1e-03
Diazinon	Fruit trees, legumes, cole crops, onions, nursery, hops, berries	1.4e-02	9.9e-03	7.0e-03	5.8e-03	4.3e-03	3.9e-03	2.4e-03
DDVP	Naled degradate	8.2e-05	2.8e-08	2.1e-12	4.9e-13	1.5e-13	9.6e-14	1.7e-14
Dimethoate	Fruit trees, legumes, cole crops, Christmas trees	2.8e-02	2.5e-03	6.8e-04	3.2e-04	1.2e-04	5.8e-05	6.5e-06
Disulfoton	Broccoli	1.1e-04	8.2e-05	6.1e-05	5.2e-05	4.1e-05	3.6e-05	2.2e-05
Ethoprop	Beans, snap	7.2e-01	6.6e-01	5.1e-01	4.1e-01	2.8e-01	2.5e-01	1.6e-01
Malathion	Apples, cherries, squash, onions, berries	1.5e-02	2.7e-03	9.2e-04	2.6e-04	3.2e-05	8.1e-06	4.5e-11
Methamidophos	Acephate degradate	7.3e-05	1.5e-06	6.4e-09	1.3e-10	2.0e-12	7.1e-13	8.1e-15
Methidathion	Pears	1.3e-04	5.5e-05	2.8e-05	1.6e-05	5.7e-06	3.5e-06	3.0e-07
Methyl Parathion	Onions	1.9e-04	5.0e-05	1.9e-05	1.2e-05	5.1e-06	3.5e-06	5.4e-07
Naled	Cole crops	1.4e-04	3.5e-06	2.6e-10	1.3e-12	7.2e-13	6.0e-13	3.0e-13
ODM	Cabbage, Christmas Trees	7.0e-04	1.4e-04	5.2e-05	3.1e-05	1.6e-05	1.3e-05	3.2e-06
Phosmet	Fruit trees	1.7e-03	1.1e-04	1.6e-06	1.8e-08	1.9e-11	2.2e-12	3.7e-13
OP Cumulative Concentration in Methamidophos Equivalents, ppb		1.4e-01	1.2e-01	9.2e-02	7.5e-02	5.1e-02	4.6e-02	3.0e-02

i. Comparison of Monitoring Data versus Model Estimates

Six OP pesticide parent compounds included in this assessment were tracked in the NAWQA study for the Willamette Valley. The upper percentile estimated concentrations for four individual OP pesticides were less than the maximum detections reported in the NAWQA monitoring for the Willamette Valley. Estimated azinphos methyl concentrations were two three orders of magnitude lower than reported detections at all percentiles. Estimated malathion concentrations were also one to two orders of magnitude lower than reported detections at all percentiles. Estimated diazinon concentrations were an order of magnitude lower than reported detections at the 95th and greater percentiles. Estimated concentrations for chlorpyrifos were similar to reported detections at all percentiles. The highest monitoring detect of

ethoprop is three times the estimated maximum peak. Neither disulfoton nor methyl parathion were detected in the Willamette Valley study. The entire estimated distributions for disulfoton and methyl parathion were below the limits of detection.

All of the maximum monitoring detects occurred in Zollner Creek. This stream has a watershed with 99% agricultural use. A comparison of distributions showed that estimated OP concentrations at percentiles of 80th or greater were generally lower (up to 2-3 orders of magnitude) than reported monitoring distributions in Zollner Creek. At lower percentiles, the concentration profiles were similar.

When the estimated concentrations are compared with the NAWQA monitoring for rest of the agricultural watersheds (with particular focus on Pudding River) in the Willamette Valley, the estimated concentrations were similar to the monitoring concentrations, except for azinphos methyl and diazinon, which were still an order of magnitude lower than maximum monitoring detections.

Zollner Creek and the Pudding River had all but two detections in the agricultural sites. For chlorpyrifos (Figure III.E.1-2), the estimated and observed concentrations were consistent except that the observed concentrations in Zollner Creek were higher at the highest percentiles. For ethoprop (Figure III.E.1-3), the estimated concentrations were slightly higher than the observed concentrations except for the highest percentiles, at which the observed concentrations were higher than the estimated. For azinphos methyl and diazinon (Figures III.E.1-4 and -5), the estimated concentrations were consistent with those observed in the Pudding River, but were consistently lower than the Zollner creek concentrations.

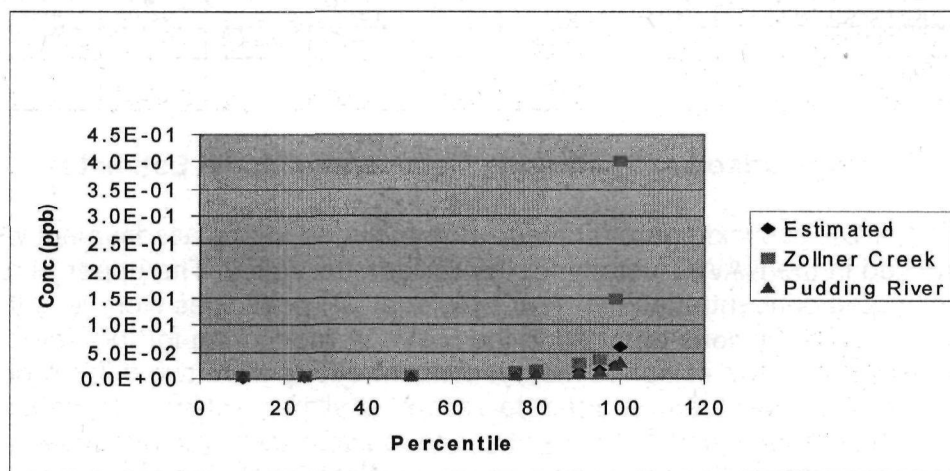


Figure III.E.1-2. Comparison of observed and estimated chlorpyrifos concentrations in the Northwest Region.

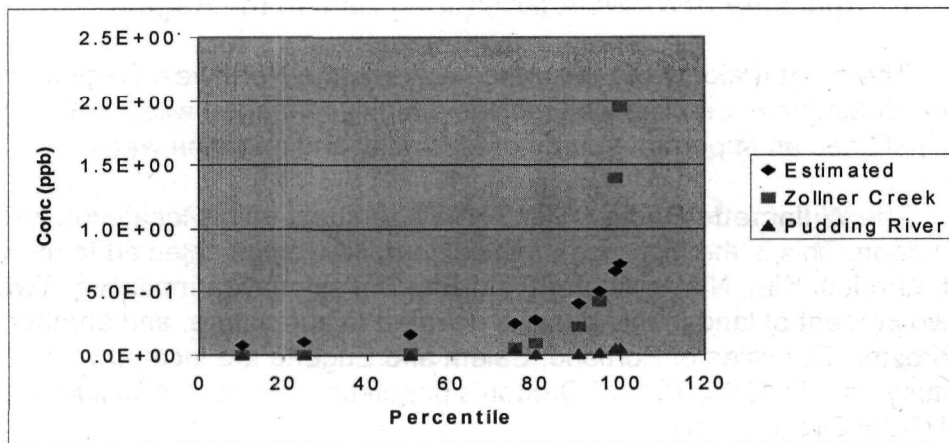


Figure III.E.1-3. Comparison of observed and estimated ethoprop concentrations in the Northwest Region.

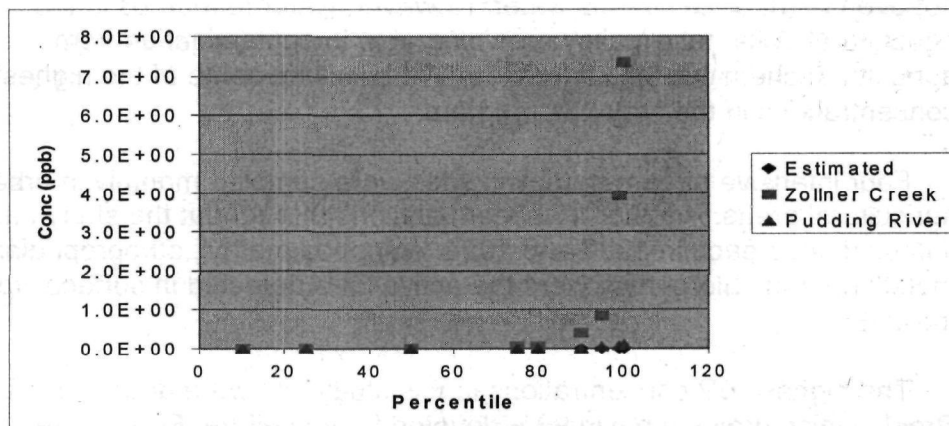


Figure III.E.1-4. Comparison of observed and estimated azinphos methyl concentrations in the Northwest Region.

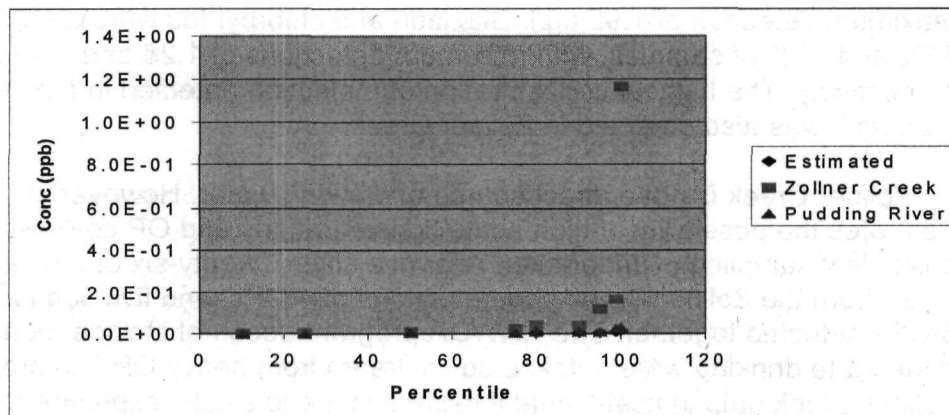


Figure III.E.1-5. Comparison of observed and estimated diazinon concentrations in the Northwest Region.

ii. Summary of NAWQA Monitoring Data in the Region

The great majority of the surface water in the Northwest Region drains to the Columbia River. The Columbia is a highly managed water body, and constitutes an important source of electricity and irrigation water.

The **Willamette Basin (WILL) NAWQA** study unit is located in western Oregon. This is the high-use, high vulnerability region selected to represent the Fruitful Rim, NW through PRZM-EXAMS simulation modeling. Twenty-two percent of land in this basin is devoted to agriculture, and another 70% to forestry. The cities of Portland, Salem and Eugene are located within this study unit. In 1990, 70% of Oregon's population lived in the Willamette Basin (USGS Circular 1161).

Surface water is the predominant source of drinking water in the area. The city of Portland derives its water from the pristine Bull Run Watershed, and is not even required to filter its water. However, water resources in the agricultural Willamette Valley are vulnerable to contamination from agricultural chemicals. Data from the WILL include some of the highest OP concentrations in the NAWQA program.

Four intensive stream-sampling sites were sampled monthly in urban and agricultural areas. Another 44 stream stations throughout the study unit were sampled once each in 1993 and 1994. Azinphos methyl, ethoprop, diazinon, malathion and chlorpyrifos were the active OPs detected in surface water of the WILL.

The highest OP concentrations in this study unit were detected in Zollner Creek, which drains a basin 99% devoted to agriculture. Forty-three pesticides in all were detected at this sampling station. Azinphos methyl was detected in 32% of samples at this site, with a maximum concentration of **7.35 ug/l**. Ethoprop was detected in 75% of Zollner Creek samples, with a maximum detection of 1.95 ug/l. Diazinon and chlorpyrifos were detected in 72% and 65% of samples, with maximum detections of 1.28 and 0.40 ug/l, respectively. The highest concentration of malathion detected in the WILL, 0.24 ug/l, was also detected in Zollner Creek.

Zollner Creek is not a direct source of drinking water. However, it illustrates the possibility of high acute concentrations and OP co-occurrence possible if sampling is undertaken near use sites. Twenty-six of the samples taken from the Zollner Creek had detections of 4 OPs, and five samples had 5 OPs detected together. The NAWQA program does not include monitoring targeted to drinking water intakes downstream from heavy OP use areas. Zollner Creek data indicates that if such a scenario exists, exposure to multiple OPs may be possible.

Ground-water studies in the WILL were designed to assess the quality of vulnerable resources. Seventy shallow domestic wells in alluvial aquifers were sampled once each, as were 53 monitoring wells in the alluvial aquifer located in irrigated and non-irrigated farmland regions. Ten further urban wells were installed near Portland, and sampled once each. Terbufos was the only OP detected, once at <0.01 ug/l.

The **Central Columbia Plateau (CCPT) NAWQA** study unit is located almost completely in the arid region of eastern Washington, spilling over into western Idaho. It is an area with extensive dryland agriculture, with irrigation from the Columbia Basin Irrigation Project in the west, and intermittent areas of ground-water irrigation. Much of the area has few, if any, natural perennial streams. The area is much less prone to surface runoff than the Willamette Valley, which was the region for surface-water modeling scenarios for the cumulative assessment.

Eighty-four percent of drinking-water supply in this region comes from ground water. However, irrigation has changed the local hydrology over the last 50 years. In the western portion of the study unit (Quincy-Pasco subunit), water from the Columbia Basin Irrigation Project has caused a rise in the water table of 50 to 500 feet. Discharge to surface-water bodies is such that NAWQA recommends sampling of irrigation wasteways as a way to monitor trends in atrazine and nitrate concentrations in this region's ground water. Ground-water withdrawals in the North-Central subunit, by contrast, has caused up to a 150-foot decline in the water table in some places.

Ground-water studies included monitoring of ground water near irrigated row crops, orchards, and dryland grains. All three studies included both domestic wells and monitoring wells near fields (generally within 100 feet for row crops and orchards, and edge-of-field for grains). Azinphos-methyl, chlorpyrifos and methyl parathion were all detected in ground water in the CCPT. Azinphos methyl was detected four times (1%) in the orchard study, with a maximum concentration of about 0.2 ug/l. Methyl parathion was detected twice in the same study (max 0.07 ug/l), but orchard uses of methyl parathion are being phased out (Roberts and Jones, 1996).

In addition to fixed sites throughout the study unit, the CCPT included four intensive sites sampling areas of potato, potato and corn, orchard, and wheat culture. **This targeted sampling resulted in greater than average agricultural detection of OPs in surface water.** Every OP included as an analyte was detected in at least one surface-water sample. For instance, azinphos methyl was detected in 16.4% of agricultural samples, with a maximum concentration of 0.5 ug/l. Ethoprop was detected in 9.2% of agricultural samples, with a maximum concentration of 0.22 ug/l. Chlorpyrifos was detected in 27% of agricultural samples, with a maximum concentration of 0.12 ug/l. Diazinon, malathion, methyl parathion, phorate and terbufos

were all detected in 6% of samples or fewer, with maximum concentrations of <0.1 ug/l.

Every OP was also detected in stream samples described as "mixed use." While the frequency of detection overall was less than in agricultural streams, the maximum concentrations were higher. For instance, the maximum concentration of disulfoton in these streams was 3.8 ug/l. The rest of the OPs were detected at < 1.0 ug/l, but mostly with maximum concentrations of above 0.1 ug/l.

Therefore, higher frequencies and concentrations of OPs were found by targeted monitoring in this semi-arid area, just as they were at the Zollner Creek in the Willamette Valley.

Only 6% of land in the **Puget Sound Basin (PUGT) NAWQA** study unit is dedicated to agriculture. Drinking water in this region is drawn about equally from surface-water and ground-water sources.

No OPs were detected in three ground-water monitoring programs sampling from the Fraser aquifer in the "Puget Lowlands." The Fraser is a shallow, unconfined, glacial aquifer which underlies the main agricultural region in the study unit. Surface-water studies in the PUGT included 4 intensive study sites (2 agricultural, 1 urban, 1 mixed-use) that were sampled weekly to monthly for a year (two for urban samples). In addition, 13 urban and residential sites were sampled 2 to 4 times each in response to detections of diazinon and other urban-use chemicals.

Diazinon was detected in 47% of agricultural surface-water samples, with a maximum concentration of 0.113 ug/l. Diazinon was detected in 84% of urban stream samples. Chlorpyrifos was only detected in urban or mixed-use samples. The only other OPs detected were malathion (1 of 20 detections from agricultural use, maximum concentration 0.087 ug/l) and ethoprop (3 detections, maximum 0.019 ug/l).

Table III.E.1-4. Magnitude and Frequency of Occurrence of OP Pesticides Analyzed in the NAWQA Study Units in the Northwest Region

Land Use	Value	chlorpyrifos	diazinon	disulfoton	ethoprop	malathion	azinphos methyl	methyl parathion	phorate	terbufos
Concentration (ug/L)										
Willamette River Basin										
All Locations	Maximum	0.401	1.280	0.021	1.950	0.237	7.350	0.006	0.011	0.017
	99th	0.060	0.192	0.021	0.558	0.029	0.914	0.006	0.011	0.017
	95th	0.023	0.061	0.021	0.099	0.027	0.081	0.006	0.011	0.017
	90th	0.014	0.029	0.017	0.033	0.020	0.050	0.006	0.002	0.013
	80th	0.008	0.013	0.017	0.009	0.005	0.001	0.006	0.002	0.013
	75th	0.006	0.009	0.017	0.005	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.003	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	39.3%	49.9%	0.0%	28.7%	4.5%	9.7%	0.0%	0.0%	0.0%
Agricultural	Maximum	0.401	1.280	0.021	1.950	0.237	7.350	0.006	0.011	0.017

Land Use	Value	chlorpyrifos	diazinon	disulfoton	ethopro-P	malathion	azinphos-methyl	methyl-parathion	phorate	terbufos
Concentration (ug/L)										
	99th	0.099	0.722	0.021	1.011	0.075	2.289	0.006	0.011	0.017
	95th	0.032	0.136	0.021	0.269	0.027	0.555	0.006	0.011	0.017
	90th	0.018	0.045	0.017	0.115	0.020	0.173	0.006	0.002	0.013
	80th	0.011	0.017	0.017	0.046	0.005	0.040	0.006	0.002	0.013
	75th	0.010	0.013	0.017	0.031	0.005	0.023	0.006	0.002	0.013
	50th	0.004	0.005	0.017	0.004	0.005	0.001	0.006	0.002	0.013
	Frequency	48.0%	59.2%	0.0%	52.3%	6.6%	20.9%	0.0%	0.0%	0.0%
Ag: Zollner Creek only	Maximum	0.401	1.280	0.021	1.950	0.237	7.350	0.006	0.011	0.017
	99th	0.147	1.167	0.021	1.402	0.136	3.927	0.006	0.011	0.017
	95th	0.036	0.165	0.021	0.421	0.027	0.854	0.006	0.011	0.017
	90th	0.029	0.119	0.021	0.227	0.027	0.415	0.006	0.011	0.017
	80th	0.017	0.037	0.017	0.099	0.010	0.050	0.006	0.002	0.013
	75th	0.014	0.025	0.017	0.063	0.005	0.050	0.006	0.002	0.013
	50th	0.006	0.010	0.017	0.018	0.005	0.001	0.006	0.002	0.013
	Frequency	64.8%	71.6%	0.0%	75.0%	6.8%	32.2%	0.0%	0.0%	0.0%
Ag Besides Zollner Creek	Maximum	0.032	0.170	0.017	0.054	0.013	0.099	0.006	0.002	0.013
	99th	0.023	0.082	0.017	0.043	0.012	0.077	0.006	0.002	0.013
	95th	0.011	0.010	0.017	0.013	0.007	0.001	0.006	0.002	0.013
	90th	0.009	0.009	0.017	0.006	0.005	0.001	0.006	0.002	0.013
	80th	0.005	0.006	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.005	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	25.0%	42.2%	0.0%	20.6%	6.3%	4.9%	0.0%	0.0%	0.0%
Forest/ Reference	Maximum	0.005	0.005	0.021	0.005	0.027	0.05	0.006	0.011	0.017
	99th	0.005	0.005	0.021	0.005	0.027	0.05	0.006	0.011	0.017
	95th	0.005	0.005	0.021	0.005	0.027	0.05	0.006	0.011	0.017
	90th	0.005	0.005	0.021	0.005	0.027	0.05	0.006	0.011	0.017
	80th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Urban	Maximum	0.046	0.112	0.021	0.009	0.052	0.171	0.006	0.011	0.017
	99th	0.046	0.105	0.021	0.009	0.042	0.126	0.006	0.011	0.017
	95th	0.040	0.067	0.021	0.007	0.027	0.050	0.006	0.011	0.017
	90th	0.029	0.057	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	80th	0.020	0.033	0.017	0.005	0.019	0.001	0.006	0.002	0.013
	75th	0.016	0.031	0.017	0.003	0.006	0.001	0.006	0.002	0.013
	50th	0.006	0.023	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	60.0%	97.5%	0.0%	13.2%	10.0%	2.6%	0.0%	0.0%	0.0%
Mixed	Maximum	0.014	0.031	0.021	0.029	0.027	0.050	0.006	0.011	0.017
	99th	0.013	0.023	0.021	0.024	0.027	0.050	0.006	0.011	0.017
	95th	0.007	0.009	0.021	0.013	0.027	0.050	0.006	0.011	0.017
	90th	0.006	0.006	0.017	0.005	0.005	0.001	0.006	0.002	0.013
	80th	0.005	0.005	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.005	0.005	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	38.3%	43.5%	0.0%	14.8%	2.6%	0.9%	0.0%	0.0%	0.0%

Land Use	Value	chlorpyrifos	diazinon	disulfoton	ethopro p	malathion	azinphos methyl	methyl parathion	phorate	terbufos
Concentration (ug/L)										
Upper Snake River										
All locations	Maximum	0.190	0.095	0.017	0.004	0.020	0.031	0.006	0.012	0.013
	99th	0.011	0.009	0.017	0.004	0.005	0.001	0.006	0.002	0.013
	95th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	90th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	80th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	3.0%	3.4%	0.0%	1.3%	0.4%	0.9%	0.0%	0.4%	0.0%
Agricultural	Maximum	0.190	0.095	0.017	0.003	0.020	0.031	0.006	0.012	0.013
	99th	0.072	0.041	0.017	0.003	0.005	0.003	0.006	0.002	0.013
	95th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	90th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	80th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	4.2%	4.2%	0.0%	0.0%	0.6%	1.2%	0.0%	0.6%	0.0%
Forest/ Reference	Maximum	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	99th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	95th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	90th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	80th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Mixed	Maximum	0.004	0.002	0.017	0.004	0.005	0.001	0.006	0.002	0.013
	99th	0.004	0.002	0.017	0.004	0.005	0.001	0.006	0.002	0.013
	95th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	90th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	80th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	0.0%	1.6%	0.0%	4.9%	0.0%	0.0%	0.0%	0.0%	0.0%
Central Columbia Plateau										
All locations	Maximum	0.120	0.270	3.810	0.220	0.130	0.500	0.300	0.062	0.096
	99th	0.088	0.059	0.024	0.059	0.027	0.128	0.091	0.011	0.017
	95th	0.022	0.010	0.017	0.005	0.012	0.055	0.006	0.002	0.013
	90th	0.009	0.005	0.017	0.004	0.005	0.040	0.006	0.002	0.013
	80th	0.004	0.002	0.017	0.003	0.005	0.010	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	18.9%	7.7%	2.1%	8.3%	3.5%	9.9%	1.3%	0.5%	0.5%

Land Use	Value	chlorpyrifos	diazinon	disulfoton	ethoprop	malathion	azinphos methyl	methyl parathion	phorate	terbufos
Concentration (ug/L)										
Agricultural	Maximum	0.120	0.100	0.035	0.220	0.093	0.500	0.094	0.045	0.087
	99th	0.116	0.052	0.022	0.107	0.027	0.134	0.007	0.011	0.017
	95th	0.057	0.005	0.017	0.005	0.011	0.072	0.006	0.002	0.013
	90th	0.016	0.002	0.017	0.004	0.005	0.050	0.006	0.002	0.013
	80th	0.006	0.002	0.017	0.003	0.005	0.013	0.006	0.002	0.013
	75th	0.005	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	26.7%	6.2%	3.1%	9.2%	5.6%	16.4%	2.1%	0.5%	0.5%
Mixed	Maximum	0.108	0.116	3.810	0.115	0.130	0.257	0.300	0.062	0.096
	99th	0.043	0.051	0.029	0.033	0.027	0.078	0.158	0.012	0.017
	95th	0.010	0.010	0.021	0.005	0.023	0.050	0.006	0.011	0.017
	90th	0.005	0.005	0.017	0.005	0.005	0.030	0.006	0.002	0.013
	80th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	11.4%	11.4%	1.1%	7.4%	1.1%	2.8%	0.6%	0.6%	0.6%
Puget Sound Basin										
All locations	Maximum	0.075	0.501	0.021	0.019	0.087	0.050	0.006	0.011	0.017
	99th	0.029	0.411	0.021	0.006	0.073	0.050	0.006	0.011	0.017
	95th	0.005	0.155	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	90th	0.005	0.107	0.017	0.003	0.027	0.001	0.006	0.002	0.013
	80th	0.004	0.050	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.031	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.005	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	2.4%	50.7%	0.0%	1.4%	9.4%	0.0%	0.0%	0.0%	0.0%
Agricultural	Maximum	0.004	0.113	0.017	0.013	0.025	0.001	0.006	0.002	0.013
	99th	0.004	0.102	0.017	0.011	0.020	0.001	0.006	0.002	0.013
	95th	0.004	0.066	0.017	0.004	0.010	0.001	0.006	0.002	0.013
	90th	0.004	0.053	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	80th	0.004	0.012	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.006	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	0.0%	47.1%	0.0%	5.9%	2.9%	0.0%	0.0%	0.0%	0.0%
Urban	Maximum	0.075	0.501	0.021	0.005	0.087	0.050	0.006	0.011	0.017
	99th	0.033	0.486	0.021	0.005	0.078	0.050	0.006	0.011	0.017
	95th	0.015	0.285	0.018	0.003	0.038	0.001	0.006	0.002	0.013
	90th	0.006	0.171	0.017	0.003	0.027	0.001	0.006	0.002	0.013
	80th	0.004	0.108	0.017	0.003	0.013	0.001	0.006	0.002	0.013
	75th	0.004	0.093	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.031	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	5.3%	84.2%	0.0%	0.0%	17.9%	0.0%	0.0%	0.0%	0.0%
Mixed	Maximum	0.005	0.083	0.021	0.019	0.027	0.050	0.006	0.011	0.017
	99th	0.005	0.060	0.021	0.008	0.027	0.050	0.006	0.011	0.017

Land Use	Value	chlorpyrifos	diazinon	disulfoton	ethoprophos	malathion	azinphos methyl	methyl parathion	phorate	terbufos
		Concentration (ug/L)								
	95th	0.005	0.011	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	90th	0.004	0.007	0.018	0.005	0.009	0.011	0.006	0.004	0.014
	80th	0.004	0.005	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	0.0%	15.2%	0.0%	1.3%	2.5%	0.0%	0.0%	0.0%	0.0%

c. Region C: Arid/Semiarid West

Estimated concentrations for individual OP pesticides in the region were in the sub-part per billion range (Table III.E.1-5). Several OPs – chlorpyrifos, diazinon, disulfoton, methidathion, and phorate– had estimated maximum concentrations of 0.1 to 0.3 ppb. At the 99th percentile level, only diazinon had an estimated concentration greater than 0.1 ppb. More detailed discussion and analysis of the OP load in drinking water sources can be found in section II.C.

Table III.E.1-5. Estimated percentile concentrations of individual OP pesticides and of the cumulative OP distribution in the Arid/Semiarid West Region.

Chemical	Crop/Use	Concentration in ug/L (ppb)						
		Max	99th	95th	90th	80th	75th	50th
Acephate	Legume vegetables, tomato	1.6e-02	1.3e-02	8.5e-03	5.0e-03	3.7e-04	1.0e-04	3.7e-06
Azinphos Methyl	Apples, pears; nuts (almonds, walnuts)	3.8e-02	5.7e-03	2.5e-03	1.8e-03	1.3e-03	1.1e-03	4.7e-04
Chlorpyrifos	Nuts; fruit trees; alfalfa; sugarbeets; corn; grapes; tomato; asparagus	1.3e-01	5.4e-02	3.7e-02	3.0e-02	2.3e-02	2.0e-02	1.2e-02
Diazinon	nuts; fruit trees; grapes; brassicas; tomato; melons	2.3e-01	1.4e-01	8.1e-02	5.6e-02	3.2e-02	2.5e-02	9.9e-03
DDVP	Naled degradate	1.3e-03	1.9e-04	9.4e-06	6.3e-07	2.6e-09	1.4e-10	8.2e-13
Dimethoate	Fruit trees; alfalfa; corn; grapes; legumes; tomatoes; brassicas; melons	8.4e-02	2.2e-02	1.6e-02	1.3e-02	8.0e-03	5.4e-03	1.4e-03
Disulfoton	Asparagus	1.2e-01	4.9e-02	3.7e-02	3.3e-02	2.8e-02	2.6e-02	1.7e-02
Malathion	Alfalfa; corn; grapes, legumes; tomatoes; asparagus	8.3e-03	1.9e-03	1.2e-03	7.9e-04	3.0e-04	1.2e-04	2.8e-08
Methamidophos	Acephate degradate; tomato; sugarbeet; legume; brassicas	1.3e-02	3.0e-03	1.6e-03	9.6e-04	3.6e-04	2.3e-04	4.6e-06
Methyl Parathion	Alfalfa	5.3e-03	2.6e-03	1.4e-03	8.6e-04	1.4e-04	4.7e-05	4.3e-08
Methidathion	Nut trees; fruit trees	1.5e-01	6.5e-02	3.5e-02	2.0e-02	8.4e-03	5.8e-03	7.6e-04
Naled	Nut trees; fruit trees; sugarbeets; grapes; legumes	4.4e-03	9.0e-04	5.3e-05	1.0e-05	2.3e-07	1.2e-08	2.1e-12
ODM	Sugarbeet; brassicas; melons	3.8e-03	2.2e-03	1.1e-03	6.7e-04	3.9e-04	3.2e-04	1.4e-04
Phorate	Sugarbeet, corn	2.6e-01	1.0e-02	5.1e-04	4.2e-05	3.5e-07	3.2e-08	3.5e-12
Phosmet	nut trees; fruit trees; alfalfa	3.2e-02	3.0e-03	6.1e-04	6.3e-05	1.4e-06	2.3e-07	1.2e-11
OP cumulative concentration in methamidophos equivalents		7.6e-01	2.2e-01	1.6e-01	1.4e-01	1.2e-01	1.1e-01	7.6e-02

i. Comparison of Monitoring Data versus Model Estimates

In comparison to NAWQA monitoring from agricultural sites in the San Joaquin-Tulare Basin, estimated concentrations for individual OP pesticides tended to be similar to or less than reported detections in the NAWQA study unit. Reported detections of azinphos methyl, malathion, and methyl parathion were an order of magnitude greater than the estimated concentrations for the 75th to 90th percentiles and greater. The 99th percentile of monitoring detections for diazinon was an order of magnitude greater than estimated concentrations. Estimated chlorpyrifos distributions through the median and diazinon distributions below the 99th percentile were similar to the distributions of monitoring concentrations in the agricultural streams. Neither phorate nor

disulfoton were detected in the NAWQA study. Approximately 99 percent of the estimated concentrations for phorate fell below the USGS analytical limit of detection (LOD). The estimated maximum concentration for disulfoton was 7 times greater than the LOD; 99th and 95th percentile estimates were roughly 2 times greater than the LOD.

Numerous co-occurrences of chlorpyrifos and diazinon were observed in many of the agricultural sites. For chlorpyrifos (Figure III.E.1-6) and diazinon (Figure III.E.1-7) concentrations in a representative water body such as Orestimba Creek, the estimated concentrations were consistent with the lower percentiles of monitoring data in Orestimba creek, but were lower at the highest percentiles.

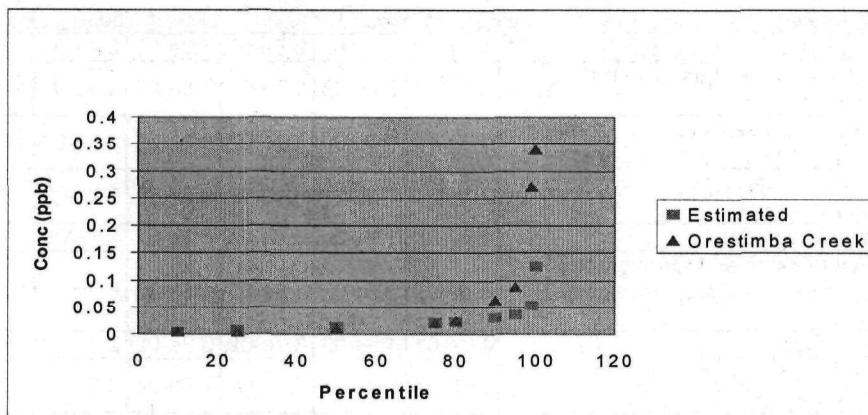


Figure III.E.1-6. Comparison of observed and estimated chlorpyrifos concentrations in the Arid/Semiarid West Region.

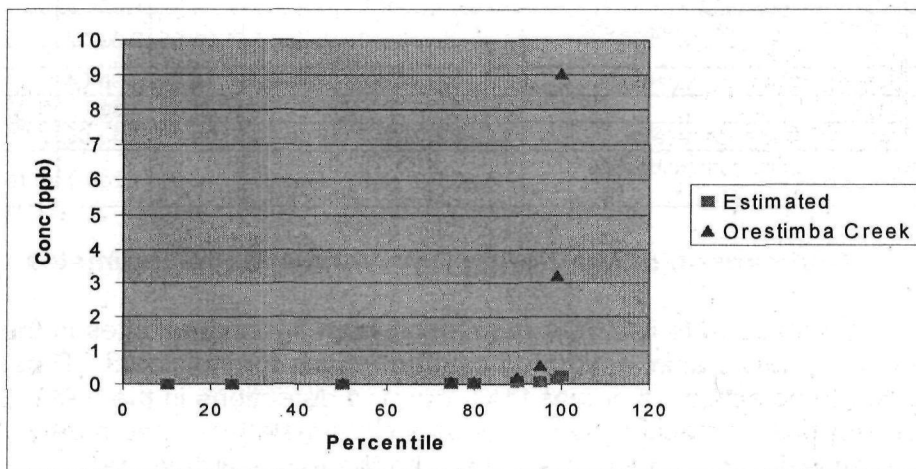


Figure III.E.1-7. Comparison of observed and estimated diazinon concentrations in the Arid/Semiarid West Region.

ii. Summary of NAWQA Monitoring Data in the Region

The **Sacramento River Basin (SACR) NAWQA** study site includes the Sacramento Valley in the West region. The Sacramento River is the largest river in the State of California, and is a highly managed water body which meets the needs of the more than one million people in the Sacramento area. The USGS indicates that while the concentrations of OP insecticides in agricultural and urban streams in this region "sometimes exceed amounts that are toxic to zooplankton in laboratory tests, the toxicity is greatly reduced or eliminated when concentrations of these pesticides are diluted by the Sacramento River" (USGS Water Resources Circular 1215).

Surface-water monitoring included 3 intensive sampling sites, including the Colusa Basin Drain, which in the late 1980s had elevated concentrations of methyl parathion and malathion detected. Since that time, a program to reduce spray drift and increase paddy-water holding time has reduced detected concentrations dramatically. A description of this program is included in the State Monitoring Appendix. An urban intensive study site was also sampled.

In the SACR study, chlorpyrifos, diazinon, malathion and azinphos-methyl were detected in surface water. Diazinon was detected in 71% of agricultural samples, and 35% of mixed land-use samples, with a maximum concentration of slightly over 0.1 ug/l. Chlorpyrifos was detected in 29% of agricultural samples, and a single mixed land-use sample, with a maximum concentration detected of about 0.05 ug/l. Malathion was detected in 53% of urban samples and 33% of agricultural samples, with a maximum detection of nearly 1 ug/l.

The **San Joaquin-Tulare Basins (SANJ) NAWQA** study site includes the southern Central Valley of California. Surface water accounts for more overall water use than ground water, but ground water is the predominant source of drinking water in this region (USGS Water Resources Circular 1159). Irrigation accounts for the greatest amount of water use, and is also the greatest source of aquifer recharge, which can lead to contamination of ground water with agricultural chemicals.

Ground-water monitoring in the SANJ included single samples from 30 domestic wells around the eastern portion of the valley. Monitoring also included in single samples from 20 domestic wells and 10 monitoring wells each in almond, vineyard and row crop land-use ground-water studies. More than 50% of the monitoring wells in each of these studies was within a quarter-mile of cropped fields. Chlorpyrifos, malathion and diazinon were detected in one, two and three ground water samples, respectively. One detection of malathion at 0.1 ug/l was the highest OP concentration detected in ground water.

The SANJ report specifically mentions that "high concentrations of organophosphate insecticides, resulting from application to some orchards during the winter, are of particular concern" (USGS Water Resources Circular 1159). Surface-water monitoring included biweekly to monthly sampling at intensive agricultural, rangeland and urban sites in 1993. Another 23 sites were sampled once at low flow in urban and agricultural areas.

Diazinon was detected in 71% of samples taken, with a maximum concentration of 3.8 ug/l. Chlorpyrifos was detected in 52 % of samples, with a maximum concentration of about 0.5 ug/l. Azinphos methyl was also extensively (12%) detected, with a maximum concentration of about 1.0 ug/l. Malathion was detected in 8% of samples, with a maximum concentration between 0.5 and 1.0 ug/l. Ethoprop, disulfoton, methyl parathion and terbufos were detected in fewer than 1% of samples analyzed.

The maximum concentrations of chlorpyrifos were detected in samples taken around the winter application season.

The USGS San Joaquin River Basin study included a study designed to determine sampling frequency needed to characterize the occurrence and distribution of pesticides in surface water in a semiarid agricultural region such as the SJRB. Results indicated that sampling three times per week is more likely to detect higher concentrations than once per week as indicated by the larger variance about the median for the more frequent sampling. Sampling once per week is sufficient if only the median concentration is important.

The **Central Arizona Basins (CAZB) NAWQA** study unit is located in southern and central Arizona. The dominant source of drinking water in central Arizona are deep basin aquifers, some of which may have been recharged thousands of years ago. At the very least, 55% of wells tested in the Central Arizona Basins NAWQA study area (CAZB) were recharged before 1953 (USGS Water Resources Circular 1213).

Alluvial deposits in the vicinity of major streams in Arizona range in thickness up to about 300 feet, and where locally saturated serve as aquifers. Chlorpyrifos was detected in a single sample from a shallow monitoring well in the CAZB study unit, but no OP was detected in samples from wells installed in the deeper aquifers. Although a single sampling of a well network is not definitive in determining the likelihood of pesticide contamination, the depth of the aquifers, combined with the very low rainfall for the region, result in very slow recharge rates which may delay contamination by OP residues for a long time.

Surface-water monitoring in this region included two intensive sampling sites from agricultural streams, and three other fixed sites which were sampled quarterly. Diazinon was detected in 97% of samples, and

chlorpyrifos in 94%, all below 0.5 ug/l. malathion was detected in 26% of samples at similar concentrations. Disulfoton was detected once at nearly 1 ug/l. Azinphos methyl, methyl parathion and phorate are also reported to have been detected in surface water.

However, while these mixed agricultural/urban streams may be effected ecologically by this contamination, they are not used as drinking water sources. The two streams (Buckeye Canal and Hassayampa River) are typical of most in the region, in that flow is maintained through addition of treated wastewater effluent and irrigation return water.

Table III.E.1-6. Magnitude and Frequency of Occurrence of OP Pesticides Analyzed in the NAWQA Study Units in the Arid/Semiarid West Region

Land Use	Value	chlorpyrifos	diazinon	disulfoton	ethionop	malathion	azinphos methyl	methyl parathion	phorate	terbufos
Concentration (ug/L)										
San Joaquin-Tulare Basins										
All Locations	Maximum	0.340	9.050	0.060	0.029	0.390	1.000	0.090	<0.06	0.100
	99th	0.182	1.148	<0.021	0.011	0.068	0.210	0.021	<0.018	0.018
	95th	0.053	0.340	<0.021	<0.005	0.027	0.056	<0.006	<0.011	<0.017
	90th	0.030	0.170	<0.021	<0.005	0.027	0.050	<0.006	<0.011	<0.017
	80th	0.015	0.080	<0.021	<0.005	<0.027	<0.050	<0.006	<0.011	<0.017
	75th	0.012	0.055	<0.017	<0.003	<0.015	<0.050	<0.006	<0.003	<0.013
	50th	0.005	0.016	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	Frequency	61.3%	83.9%	0.1%	1.2%	13.8%	10.5%	0.3%	0.0%	0.3%
Agricultural	Maximum	0.340	9.050	<0.050	0.029	0.390	1.000	0.090	<0.06	0.100
	99th	0.258	2.180	<0.021	0.018	0.126	0.276	0.056	<0.047	0.020
	95th	0.085	0.360	<0.021	<0.005	0.027	0.099	<0.006	<0.011	<0.017
	90th	0.042	0.160	<0.021	<0.005	0.027	0.060	<0.006	<0.011	<0.017
	80th	0.025	0.082	<0.017	<0.003	<0.009	0.050	<0.006	<0.003	<0.013
	75th	0.019	0.066	<0.017	<0.003	<0.005	0.045	<0.006	<0.002	<0.013
	50th	0.008	0.020	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	Frequency	66.9%	85.3%	0.0%	2.9%	12.6%	24.6%	0.6%	0.0%	0.3%
Mixed	Maximum	0.260	2.900	<0.021	0.010	0.160	0.400	0.018	<0.06	0.024
	99th	0.069	0.764	<0.021	<0.005	0.037	0.059	<0.006	<0.011	<0.017
	95th	0.030	0.230	<0.021	<0.005	0.027	<0.050	<0.006	<0.011	<0.017
	90th	0.017	0.150	<0.021	<0.005	0.027	<0.050	<0.006	<0.011	<0.017
	80th	0.011	0.067	<0.021	<0.005	<0.027	<0.050	<0.006	<0.011	<0.017
	75th	0.009	0.047	<0.021	<0.005	<0.019	<0.050	<0.006	<0.011	<0.017
	50th	0.005	0.013	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.017
	Frequency	57.4%	82.9%	0.0%	0.3%	12.2%	3.2%	0.2%	0.0%	0.3%
Sacramento R. Basin										
All Locations	Maximum	0.045	1.380	<0.021	<0.005	0.634	0.500	<0.006	<0.011	<0.017
	99th	0.033	0.780	<0.021	<0.005	0.139	0.237	<0.006	<0.011	<0.017
	95th	0.019	0.425	<0.021	<0.005	0.054	<0.050	<0.006	<0.011	<0.017
	90th	0.015	0.296	<0.021	<0.005	0.028	<0.050	<0.006	<0.011	<0.017
	80th	0.007	0.177	<0.017	<0.003	0.027	<0.017	<0.006	<0.002	<0.013

Land Use	Value	chlorpyrifos	diazinon	disulfoton	ethoprop	malathion	azinphos methyl	methyl parathion	phorate	terbufos
Concentration (ug/L)										
Agricultural	75th	0.005	0.089	<0.017	<0.003	0.027	<0.001	<0.006	<0.002	<0.013
	50th	<0.004	0.009	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	Frequency	26.5%	67.7%	0.0%	0.0%	25.2%	1.3%	0.0%	0.0%	0.0%
	Maximum	0.016	0.106	<0.021	<0.005	0.054	<0.050	<0.006	<0.011	<0.017
	99th	0.016	0.103	<0.021	<0.005	0.053	<0.050	<0.006	<0.011	<0.017
	95th	0.016	0.082	<0.021	<0.005	0.036	<0.050	<0.006	<0.011	<0.017
	90th	0.014	0.063	<0.021	<0.005	0.027	<0.050	<0.006	<0.011	<0.017
	80th	0.008	0.034	<0.017	<0.003	0.027	<0.001	<0.006	<0.002	<0.013
	75th	0.005	0.030	<0.017	<0.003	0.023	<0.001	<0.006	<0.002	<0.013
	50th	<0.004	0.008	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	Frequency	26.5%	76.5%	0.0%	0.0%	29.4%	0.0%	0.0%	0.0%	0.0%
Urban	Maximum	0.045	1.380	<0.021	<0.005	0.634	0.500	<0.006	<0.011	<0.017
	99th	0.041	1.186	<0.021	<0.005	0.458	0.464	<0.006	<0.011	<0.017
	95th	0.032	0.751	<0.021	<0.005	0.137	0.159	<0.006	<0.011	<0.017
	90th	0.026	0.563	<0.017	<0.003	0.083	<0.062	<0.006	<0.002	<0.013
	80th	0.020	0.434	<0.017	<0.003	0.055	<0.024	<0.006	<0.002	<0.013
	75th	0.017	0.410	<0.017	<0.003	0.048	<0.001	<0.006	<0.002	<0.013
	50th	0.009	0.275	<0.017	<0.003	0.015	<0.001	<0.006	<0.002	<0.013
	Frequency	78.4%	100.0%	0.0%	0.0%	56.8%	2.7%	0.0%	0.0%	0.0%
Mixed	Maximum	0.006	0.154	<0.021	<0.005	0.027	<0.050	<0.006	<0.011	<0.017
	99th	0.005	0.071	<0.021	<0.005	0.027	<0.050	<0.006	<0.011	<0.017
	95th	<0.005	0.049	<0.021	<0.005	0.027	<0.050	<0.006	<0.011	<0.017
	90th	<0.005	0.035	<0.021	<0.005	<0.027	<0.050	<0.006	<0.011	<0.017
	80th	<0.005	0.015	<0.019	<0.004	<0.024	<0.028	<0.006	<0.006	<0.015
	75th	<0.004	0.011	<0.017	<0.003	<0.01	<0.001	<0.006	<0.002	<0.013
	50th	<0.004	0.003	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	Frequency	3.6%	50.0%	0.0%	0.0%	9.5%	1.2%	0.0%	0.0%	0.0%
Central Arizona Basin										
All Locations	Maximum	0.154	0.207	0.826	<0.005	0.270	0.300	0.521	0.080	<0.017
	99th	0.152	0.132	0.775	<0.005	0.256	0.242	0.503	0.013	<0.017
	95th	0.067	0.111	0.021	<0.005	0.243	0.091	0.256	0.011	<0.017
	90th	0.047	0.102	<0.018	<0.003	0.118	0.050	0.036	<0.010	<0.013
	80th	0.029	0.082	<0.017	<0.003	0.027	0.006	<0.006	<0.002	<0.013
	75th	0.025	0.077	<0.017	<0.003	0.015	<0.001	<0.006	<0.002	<0.013
	50th	0.016	0.056	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	Frequency	82.7%	82.7%	4.1%	0.0%	24.5%	1.0%	9.2%	5.1%	0.0%
Agricultural	Maximum	0.154	0.207	0.826	<0.003	0.270	0.300	0.521	0.080	<0.013
	99th	0.153	0.170	0.801	<0.003	0.263	0.204	0.512	0.047	<0.013
	95th	0.122	0.083	0.747	<0.003	0.252	<0.074	0.453	0.011	<0.013
	90th	0.067	0.079	<0.017	<0.003	0.160	<0.032	0.259	0.004	<0.013
	80th	0.047	0.070	<0.017	<0.003	0.017	<0.001	0.036	<0.002	<0.013
	75th	0.038	0.058	<0.017	<0.003	0.013	<0.001	<0.006	<0.002	<0.013
	50th	0.020	0.037	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013

Land Use	Value	chlorpyrifos	diazinon	disulfoton	ethoprop	malathion	azinphos methyl	methyl parathion	phorate	terbufos
	Frequency	93.8%	89.6%	8.3%	0.0%	29.2%	2.1%	18.8%	10.4%	0.0%
Mixed	Maximum	0.043	0.123	<0.017	<0.003	0.243	<0.24	<0.006	<0.002	<0.013
	99th	0.039	0.119	<0.017	<0.003	0.213	<0.226	<0.006	<0.002	<0.013
	95th	0.032	0.112	<0.017	<0.003	0.131	<0.12	<0.006	<0.002	<0.013
	90th	0.029	0.110	<0.017	<0.003	0.119	<0.048	<0.006	<0.002	<0.013
	80th	0.025	0.103	<0.017	<0.003	0.018	<0.001	<0.006	<0.002	<0.013
	75th	0.024	0.100	<0.017	<0.003	0.006	<0.001	<0.006	<0.002	<0.013
	50th	0.017	0.074	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	Frequency	94.6%	100.0%	0.0%	0.0%	27.0%	0.0%	0.0%	0.0%	0.0%

d. Region D: Northeast/ North Central

Terbufos, which accounted for three-fourths of total OP use in the assessment area, dominated the cumulative load for the region (Table III.E.1-7). More detailed discussion and analysis of the OP load in drinking water sources can be found in section II.D.

Table III.E.1-7. Predicted percentile concentrations of individual OP pesticides and of the cumulative OP distribution in the Northeast/North Central Region.

Chemical	Crop/Use	Concentrations in ug/L (ppb)						
		Max	99th	95th	90th	80th	75th	50th
AzinphosMethyl	Potato	4.9e-02	2.2e-02	1.2e-02	7.2e-03	4.2e-03	3.1e-03	7.0e-04
Chlorpyrifos	Sugarbeet, Wheat	4.7e-02	2.6e-02	1.5e-02	1.1e-02	6.2e-03	4.7e-03	1.4e-03
Dimethoate	Potato	3.8e-02	7.4e-03	2.8e-03	1.1e-03	2.2e-04	1.2e-04	1.6e-05
Phorate	Sugar beet	5.6e-02	2.5e-03	7.9e-05	2.8e-06	2.9e-09	8.2e-11	3.8e-13
Terbufos	Sugar beet	1.9e+00	5.9e-01	1.9e-01	7.9e-02	2.0e-02	1.1e-02	1.7e-03
OP Cumulative Concentrations in Methamidophos equivalents		4.9e+00	1.5e+00	4.8e-01	2.0e-01	5.5e-02	3.0e-02	5.5e-03

i. Comparison of Monitoring Data versus Model Estimates

A comparison of estimated concentrations for individual OP pesticides with NAWQA monitoring indicates that the predicted maximum and 99th percentile concentrations of chlorpyrifos, azinphos methyl, and phorate were similar to monitoring detections in the Red River Basin. The highest reported detection for terbufos was equivalent to the estimated 90th percentile concentration. However, the model estimates include the more persistent and mobile sulfone and sulfoxide residues, while the monitoring only represents the parent concentrations.

In the 28 agricultural sampling sites, only the Snake River (combined locations), Turtle River, and the Tamarac River had any detections of OP's. Neither terbufos nor phorate were detected. However, it is important to note that parent terbufos and phorate rapidly form sulfoxide and sulfone metabolites, and the analytical method may be for parent only. Azinphos methyl, was the only OP detected from a site other than the Snake River and the Turtle River. Estimated and observed concentrations of cchlorpyrifos (Figure III.E.1-8) were consistent throughout all percentiles.

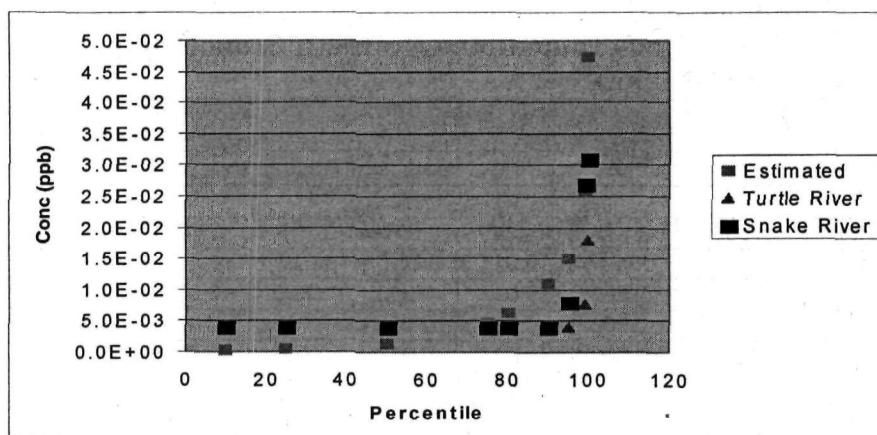


Figure III.E.1-8. Comparison of observed and estimated chlopyrifos concentrations in the Northeast/North Central Region.

In the preliminary assessment, the estimated peak and upper percentile concentrations of chlorpyrifos in the Heartland region (central Illinois) are roughly equivalent to the concentrations detected in the agricultural watersheds of the Lower Illinois River Basin (LIRB) while the maximum estimated concentration of total terbufos residues (parent plus toxic sulfoxide and sulfone transformation products) was an order of magnitude greater than the maximum detection reported for the parent terbufos (without the transformation products) in the LIRB. The maximum detection of terbufos in NAWQA fell between the 90th and 95th percentile of estimated concentrations to total terbufos residues. Between 80 and 90 percent of the estimated terbufos concentrations were below the analytical level of detection.

ii. Summary of NAWQA Monitoring Data in the Region

Stream-water sampling in the **Red River of the North Basin (REDN)** NAWQA study unit included a study of intensive agriculture areas, in which 5 stations were sampled at least monthly and during runoff events between 1993 and 1995. Chlorpyrifos is the OP most often detected in the REDN study unit. Chlorpyrifos was detected in 14 samples, but only five of these were samples from streams identified as "agricultural" (maximum concentration 0.031 ug/l). The nine other chlorpyrifos detections, and the three reported diazinon detections, were from "mixed land-use" (MLU) streams, and may not represent agricultural contamination. Malathion, disulfoton, ethoprop, methyl parathion, phorate, terbufos, and azinphos methyl were also detected in surface water samples.

Malathion is the only OP which was detected in ground water. This single detection was at a concentration below 0.01 ug/l. this sample was taken from the unconsolidated glacial aquifer. No pesticides of any kind (including herbicides) were detected in five samples from buried glacial aquifers or six samples from older bedrock aquifers (Cowdery, 1998).

Table III.E.1-8. Magnitude and Frequency of Occurrence of OP Pesticides Analyzed in the NAWQA Study Units in the Northern Great Plains Portion of the Northeast/North Central Region.

Land Use	Value	chlorpyrifos	diazinon	disulfoton	ethoprop	malathion	azinphos methyl	methyl parathion	phorate	terbufos
Concentration (ug/L)										
Red River Basin										
All Locations	Maximum	0.087	0.104	0.080	0.099	0.290	0.117	0.114	0.078	0.080
	99th	0.020	0.004	<0.017	0.004	0.020	<0.001	0.010	<0.002	<0.013
	95th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	90th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	80th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	75th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	50th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	Frequency	4.5%	1.0%	0.3%	0.6%	3.5%	0.6%	1.0%	0.3%	0.3%
Agriculture	Maximum	0.031	<0.005	<0.020	0.004	0.290	0.01	<0.010	<0.020	<0.013
	99th	0.018	<0.002	<0.017	<0.004	0.016	<0.003	<0.006	<0.002	<0.013
	95th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	90th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	80th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	75th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	50th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	Frequency	2.8%	0.0%	0.0%	0.6%	1.7%	0.6%	0.0%	0.0%	0.0%
Mixed	Maximum	0.087	0.104	0.080	0.0992	0.107	0.117	0.114	0.078	0.080
	99th	0.028	0.009	<0.017	<0.003	0.036	<0.001	0.068	<0.012	<0.013
	95th	<0.004	<0.002	<0.017	<0.003	0.009	<0.001	<0.006	<0.002	<0.013
	90th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	80th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	75th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	50th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	Frequency	7.2%	2.4%	0.8%	0.8%	6.3%	0.8%	2.4%	0.8%	0.8%
Upper Mississippi River Basin										
All Locations	Maximum	0.060	0.190	<0.021	0.020	0.0543	0.0148	<0.006	<0.011	<0.017
	99th	0.007	0.102	<0.021	<0.005	0.042	<0.137	<0.006	<0.011	<0.017
	95th	<0.004	0.053	<0.017	<0.003	<0.015	<0.001	<0.006	<0.002	<0.013
	90th	<0.004	0.022	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	80th	<0.004	0.007	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	75th	<0.004	<0.004	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	50th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	Frequency	1.7%	24.3%	0.0%	0.6%	3.2%	0.3%	0.0%	0.0%	0.0%
Agricultural	Maximum	<0.060	<0.005	<0.021	0.020	0.0061	<0.050	<0.006	<0.011	<0.017
	99th	<0.020	<0.005	<0.021	0.009	0.150	<0.050	<0.006	<0.011	<0.017
	95th	<0.004	<0.002	<0.017	<0.004	<0.027	<0.001	<0.006	<0.002	<0.013
	90th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	80th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	75th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	50th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	Frequency	0.0%	0.0%	0.0%	2.7%	1.4%	0.0%	0.0%	0.0%	0.0%

Land Use	Value	chlorpyrifos	diazinon	disulfoton	ethoprop	malathion	azinphos methyl	methyl parathion	phorate	terbufos
		Concentration (ug/L)								
Urban	Maximum	0.064	0.300	<0.021	<0.005	0.078	0.039	<0.006	<0.011	0.033
	99th	0.040	0.232	<0.021	<0.005	0.027	0.039	<0.006	<0.011	0.018
	95th	0.021	0.113	<0.017	<0.003	0.020	<0.007	<0.006	<0.002	<0.013
	90th	0.015	0.060	<0.017	<0.003	0.010	<0.001	<0.006	<0.002	<0.013
	80th	0.008	0.028	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	75th	0.005	0.020	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	50th	<0.004	0.004	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	Frequency	32.6%	59.1%	0.0%	0.0%	11.4%	2.3%	0.0%	0.0%	0.8%
Mixed	Maximum	0.006	0.009	<0.021	<0.005	0.0051	0.400	<0.006	<0.011	<0.017
	99th	0.005	0.008	<0.021	<0.005	<0.027	0.200	<0.006	<0.011	<0.017
	95th	<0.004	0.006	<0.017	<0.003	<0.005	<0.040	<0.006	<0.002	<0.013
	90th	<0.004	0.004	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	80th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	75th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	50th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	Frequency	2.0%	13.2%	0.0%	0.0%	0.7%	0.0%	0.0%	0.0%	0.0%

In the corn-soybean dominated **Lower Illinois River Basin (LIRB)** unit, chlorpyrifos and diazinon were the OPs most often detected in surface water, with peak concentrations detected in July and August. Diazinon was detected in 30% of samples overall (75 detections), but in <5% of agricultural streams (8 detections), with a maximum agricultural concentration of 0.071 ug/l. By contrast, 29 of the 37 detections of chlorpyrifos were in agricultural streams (18% of samples from agricultural areas), with a maximum concentration of 0.30 ug/l. Malathion (four detections, maximum 0.027 ug/l), methyl parathion (1 detection, 0.211 ug/l), and terbufos (3 detections, max 0.03 ug/l) were also detected in surface water. All but one detection of malathion were in streams draining agricultural areas.

Only one detection of diazinon (0.01 ug/l) was reported for all OPs in ground water. This detection occurred in one of 60 samples taken from domestic and public supply wells in "major aquifers" in the study unit. No OPs were detected in a land-use study in which "very shallow monitoring wells" were sampled in areas of corn and soybean production. The ground water that was sampled from the 57 wells was generally less than 10 years old.

The **White River Basin (WHIT)** study unit is located in central and southern Indiana. Agriculture accounts for 70% of land use in the study unit, with corn and soy as the predominant crops. As in the LIRB, atrazine and metolachlor were detected in all samples. Sampling took place between 1992 and 1996.

Diazinon, chlorpyrifos and malathion were the OPs most extensively detected in surface water. Diazinon was extensively (25%) detected in

streams draining agricultural areas, with a maximum detection of 0.41 ug/l. When urban and mixed land-use samples are included, however, diazinon was detected at even greater frequency and concentration (54.4%, max 1.1 ug/l in 801 urban stream samples). The same was true for chlorpyrifos (agricultural max 0.12 ug/l) and malathion (overall max 0.67 ug/l), which were detected at half the frequency in surface water draining agricultural areas alone than in the whole data set.

Azinphos methyl (8 detections), methyl parathion, ethoprop, terbufos and disulfoton (1 detection) were the other active OPs detected in surface water, in descending order of frequency. Of these, only ethoprop had a detection above 0.1 ug/l (one sample at 0.14 ug/l). Terbufos, the OP with the highest RPF value, was detected at concentrations of 0.013 and 0.016 ug/l.

The **Eastern Iowa (EIWA)** study unit comprises most of eastern Iowa, and a very small portion of southern Minnesota. Agriculture accounts for 90% of land use in the study unit.

Chlorpyrifos (urban and agricultural) and malathion (1 urban well sample) were detected in shallow alluvial aquifer. They were not detected in the deeper carbonate aquifer. Chlorpyrifos was detected in 16 and 10 percent of shallow ground-water wells in agricultural and urban areas, respectively, much more than the 1 % national average.

Chlorpyrifos was detected in 7 percent of agricultural streams, and 6 percent of mixed land-use streams. Diazinon (2 samples, .005 and .006) and malathion (9 samples, max 0.078) were also detected in surface water. By contrast, herbicides atrazine and malathion were detected in every surface water sample collected.

Table III.E.1-9. Magnitude and Frequency of Occurrence of OP Pesticides Analyzed in the NAWQA Study Units in the Heartland Portion of the Northeast/ North Central Region.

Land Use	Value	chlorpyrifos	diazinon	disulfoton	ethoprop	malathion	azinphos methyl	methyl parathion	phorate	terbufos
Concentration (ug/L)										
Lower Illinois R. Basin										
All Locations	Maximum	0.300	0.071	0.021	0.005	0.027	0.500	0.211	0.011	0.030
	99th	0.263	0.038	0.021	0.005	0.027	0.087	0.006	0.011	0.017
	95th	0.083	0.029	0.017	0.003	0.006	0.024	0.006	0.002	0.013
	90th	0.040	0.021	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	80th	0.007	0.012	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.005	0.010	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	15.5%	30.6%	0.0%	0.0%	1.6%	0.0%	0.4%	0.0%	1.2%
Agriculture										
Agriculture	Maximum	0.300	0.017	0.021	0.005	0.027	0.5	0.211	0.011	0.030
	99th	0.300	0.011	0.018	0.004	0.015	0.050	0.006	0.005	0.018
	95th	0.117	0.004	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	90th	0.050	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013

Land Use	Value	chlorpyrifos	diazinon	disulfoton	ethoprop	malathion	azinphos methyl	methy lparathion	phorate	terbufos
Concentration (ug/L)										
	80th	0.010	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.005	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	18.0%	4.8%	0.0%	0.0%	1.8%	0.0%	0.6%	0.0%	1.8%
Mixed	Maximum	0.090	0.071	0.021	0.005	0.027	0.300	0.006	0.011	0.017
	99th	0.067	0.054	0.021	0.005	0.027	0.142	0.006	0.011	0.017
	95th	0.042	0.037	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	90th	0.024	0.031	0.017	0.003	0.005	0.050	0.006	0.002	0.013
	80th	0.005	0.025	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.022	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.014	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	10.4%	83.8%	0.0%	0.0%	1.3%	0.0%	0.0%	0.0%	0.0%
Eastern Iowa										
All Locations	Maximum	0.400	0.057	0.021	0.004	0.078	0.800	0.006	0.011	0.017
	99th	0.070	0.007	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	95th	0.010	0.005	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	90th	0.005	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	80th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	5.3%	3.4%	0.0%	0.4%	1.1%	0.0%	0.0%	0.0%	0.0%
Agricultural	Maximum	0.400	0.006	0.021	0.005	0.078	0.1	0.006	0.011	0.017
	99th	0.039	0.005	0.021	0.005	0.027	0.054	0.006	0.011	0.017
	95th	0.009	0.005	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	90th	0.005	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	80th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	6.4%	0.7%	0.0%	0.0%	1.4%	0.0%	0.0%	0.0%	0.0%
Mixed	Maximum	0.400	0.057	0.021	0.005	0.027	0.800	0.006	0.011	0.017
	99th	0.122	0.011	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	95th	0.013	0.005	0.017	0.003	0.005	0.006	0.006	0.002	0.013
	90th	0.005	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	80th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	4.0%	6.4%	0.0%	0.8%	0.8%	0.0%	0.0%	0.0%	0.0%
White River Basin										
All Locations	Maximum	0.300	1.100	0.050	0.14	0.670	0.046	0.011	0.060	0.016
	99th	0.080	0.380	0.050	0.015	0.050	0.050	0.015	0.020	0.050
	95th	0.025	0.130	0.021	0.005	0.027	0.015	0.006	0.011	0.017
	90th	0.015	0.058	0.017	0.003	0.011	0.001	0.006	0.002	0.013
	80th	0.009	0.025	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.006	0.017	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.005	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	23.1%	54.4%	0.1%	1.2%	9.9%	1.0%	0.4%	0.0%	0.2%
Agricultural	Maximum	0.120	0.410	0.021	0.014	0.330	0.046	0.010	0.060	0.013
	99th	0.065	0.123	0.021	0.005	0.027	0.046	0.006	0.011	0.017
	95th	0.014	0.024	0.017	0.003	0.013	0.002	0.006	0.002	0.013
	90th	0.006	0.011	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	80th	0.004	0.004	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013

Land Use	Value	chlorpyrifos	diazinon	disulfoton	ethoprop	malathion	azinphos methyl	methy lparathion	phorate	terbufos
		Concentration (ug/L)								
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	10.9%	24.0%	0.0%	0.3%	5.1%	1.6%	0.6%	0.0%	0.3%
Mixed	Maximum	0.180	0.180	0.050	0.015	0.033	0.007	0.011	0.060	0.016
	99th	0.128	0.066	0.050	0.015	0.027	0.050	0.015	0.020	0.050
	95th	0.045	0.034	0.050	0.005	0.015	0.015	0.006	0.020	0.050
	90th	0.018	0.023	0.021	0.005	0.005	0.010	0.006	0.011	0.017
	80th	0.010	0.014	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.007	0.012	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.006	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	17.4%	62.8%	0.3%	1.0%	2.9%	0.3%	0.3%	0.0%	0.3%
Urban	Maximum	0.300	1.100	0.021	0.140	0.670	0.011	0.006	0.060	0.017
	99th	0.088	0.600	0.021	0.019	0.405	0.011	0.006	0.060	0.017
	95th	0.026	0.358	0.017	0.005	0.046	0.016	0.006	0.011	0.013
	90th	0.020	0.240	0.017	0.003	0.027	0.001	0.006	0.002	0.013
	80th	0.014	0.136	0.017	0.003	0.014	0.001	0.006	0.002	0.013
	75th	0.012	0.100	0.017	0.003	0.010	0.001	0.006	0.002	0.013
	50th	0.005	0.043	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	55.1%	93.8%	0.0%	3.4%	30.7%	1.1%	0.0%	0.0%	0.0%

The Lake Erie-Lake Saint Clair Drainages (LERI) NAWQA study unit assessed the water quality of streams draining to these lakes in parts of Michigan, Ohio, Indiana, New York and Pennsylvania. Although historic industrial pollution on the shores of the Great Lakes has led to the identification of the AOCs mentioned above, about 75% of the area included in this study unit is dedicated to agricultural use. Insecticides were included in weekly to monthly sampling at 4 sites from 1996 to 1998. The streams sampled drain watersheds with areas from 310 to 6330 square miles.

Chlorpyrifos and diazinon were extensively detected in agricultural, mixed land-use and urban stream samples. Both were more frequently detected in urban samples than agricultural samples (36% vs 13% for chlorpyrifos, 70% vs 23% for diazinon). The maximum agricultural stream concentration of chlorpyrifos was about 0.4 ug/l. The maximum agricultural stream concentration of diazinon was 0.1 ug/l. Malathion and methyl parathion are also listed as infrequent contaminants in this study.

Eighty percent of the population of the Hudson River Basin (HDSN) NAWQA study unit, which is located almost completely in New York, derives its drinking water from surface water supply. People drawing water from domestic wells do so mostly from unconsolidated surficial glacial and post-glacial aquifers. The region has more land devoted to forest than agriculture (62% versus 25%).

Surface-water monitoring for OPs in this study unit was limited to the 46 fixed sampling sites distributed through the basin. Diazinon was extensively detected (16%), with a maximum concentration of 0.697 ug/l. While the highest detection of diazinon was from an agricultural stream, fewer than 20% of the samples with detections of diazinon were from agricultural

streams. Chlorpyrifos was detected in little more than 1% of agricultural streams, with a maximum detection of 0.024 ug/l. Malathion was detected in 6% of urban streams, with a maximum detection of 0.13 ug/l.

Diazinon and malathion were detected in ground water in this study unit. The monitoring program included single samples from shallow (<50 feet deep) monitoring wells (26 urban, 18 agricultural) in the unconsolidated glacial and post-glacial deposits, and domestic wells throughout the region ranging in depth from 7 to more than 100 feet deep. Diazinon was detected in domestic and urban wells (2% of all wells, max detection <0.1 ug/l). Malathion was detected in about 5% of domestic wells (1% overall, max concentration <0.05 ug/l).

The Connecticut, Housatonic and Thames River Basins (CONN) NAWQA study unit includes parts of Connecticut, Massachusetts, New Hampshire, New York and Vermont, and includes only 12 % agricultural land (most is forested and undeveloped). Surface water is the predominant drinking water supply, although 924 thousand of the 4.5 million people in the region had domestic wells in 1990 (USGS Circular 1155).

The fixed site surface water sampling program in this study included 12 sites around the basin sampled about 15 times per year. In addition, a single intensive urban stream site was sampled about 40 times per year in 1993 and 1994. Diazinon was frequently detected in surface water, including a 92% frequency in urban stream samples. Chlorpyrifos (max concentration <0.1 ug/l) and disulfoton (max concentration <0.01 ug/l) were detected in 1% and <1% of samples, respectively. Malathion, however, was detected in 4% of samples, with a maximum concentration of 7.5 ug/l. This detection did not occur in an agricultural stream.

Although other insecticides such as carbofuran and permethrin were detected in ground water, and although diazinon was detected extensively in surface water, no OPs were detected in ground water in this study unit. The monitoring network included 163 wells sampled once each, with 120 of these in surficial aquifers. An additional 14 wells were sampled for a flowpath.

The New Jersey-Long Island Coastal Drainages (LINJ) NAWQA study unit includes mixed-use and urban stream samples, and agricultural, mixed use and urban ground water samples. Only seven surface water samples were collected in a stream considered to drain solely agricultural land.

An nearly equivalent number of people in the LINJ study unit derive their drinking water from surface water as from surficial aquifers. The surficial aquifers in both the southern half of New Jersey and Long Island are coarse grained soils which are susceptible to pesticide contamination.

Chlorpyrifos and diazinon were detected extensively in urban and mixed use surface water samples. Urban uses of chlorpyrifos and diazinon are currently being phased out. Only three of the urban and mixed land-use surface-water sampling sites had more than 50% agricultural land use. It is not possible to distinguish chlorpyrifos and diazinon in these samples derived from agricultural or urban/suburban use. Neither chlorpyrifos nor diazinon were detected in ground water.

The population of the **Lower Susquehanna River Basin (LSUS)** NAWQA study unit, which is located in south-central Pennsylvania and northeasternmost Maryland, derives 75% of its public water supply from surface-water sources. Public supply in this region served 1.2 million people in 1992. Another 800,000 derived their drinking water from private domestic wells. The land use in the majority of this region is equally divided between agricultural and forested land (47% each- USGS Circular 1168).

The LSUS is a study unit with relatively high frequency of OPs in surface water. Many of these correspond with tree fruit uses simulated in PRZM-EXAMS modeling for this region. Azinphos-methyl, for instance, was detected in 9% of agricultural stream samples, with a maximum concentration of 0.4 ug/l. Chlorpyrifos was detected in about 18% of agricultural streams (maximum concentration 0.09 ug/l), and diazinon was detected in little over 5% in agricultural streams (maximum concentration 0.055 ug/l). Methyl parathion, which will no longer be used on tree fruits, was detected in 2 agricultural stream samples, with a maximum concentration of 0.063 ug/l. In the LSUS, 187 sites sampled were once, 3 sites sampled intensively from 1993 to 1995.

Other OPs not included in the simulation modeling for the Northern Crescent were detected in the LSUS study. Malathion was detected in 8% of urban samples, and 3% of agricultural samples, with a maximum concentration of 0.129 ug/l. Ethoprop was detected in 1.4% of samples (8 detections), with a maximum concentration of 0.052 ug/l.

Diazinon is the only OP detected in ground water. It was detected in 2 samples at concentrations <0.01 ug/l.

The **Western Lake Michigan Drainage (WMIC)** NAWQA study unit provides further data on OP contamination in the Great Lakes region, covering eastern Wisconsin and part of the Upper Peninsula of Michigan. Agriculture accounts for 37% of the land use in this region, while 50% is forested. Drinking water is predominantly derived from surface-water supplies in this area, mostly from Lakes Michigan and Winnebago.

Pesticides were included as analytes at three intensive stream sampling sites, and at 145 other sampling sites in agricultural, urban and mixed land-use areas. Diazinon was the OP most detected in this region (5%), with

detections ranging to about 0.05 ug/l. Chlorpyrifos, phorate, malathion and methyl parathion were detected in no more than 3 samples each. The maximum detection among these was a phorate detection of about 0.1 ug/l.

The Upper Mississippi River Basin NAWQA study unit is located predominantly in Minnesota, with a small number of samples taken as well in Wisconsin and Iowa.

Although stream-water samples were collected from streams representing various land uses, urban streams accounted for nearly all of the OP detections in surface water in this study unit. Diazinon was detected in 9% of urban stream samples, and 48% of mixed land-use samples (maximum concentration 0.3 ug/l), but in none of the 50 agricultural stream samples collected. Similarly, chlorpyrifos was detected in 32% of urban streams, but not in any agricultural samples. Malathion was detected in 11% of urban samples (maximum concentration 0.08 ug/l), but only a single agricultural sample. Two detections of ethoprop (maximum concentration 0.02 ug/l) represent the only other OP detections in agricultural streams.

Diazinon was detected in four ground-water samples taken from wells in "major aquifers." The maximum concentration detected was greater than 10 ug/l, which represented the highest concentration of diazinon in ground water detected in the NAWQA program.

Table III.E.1-11. Magnitude and Frequency of Occurrence of OP Pesticides Analyzed in the NAWQA Study Units in the Northern Crescent Portion of the Northeast/ North Central Region.

Land Use	Value	chlorpyrifos	diazinon	disulfoton	ethoprop	malathion	azinphos methyl	methyl parathion	phorate	terbufos
Concentration (ug/L)										
Lower Susquehanna River Basin										
All Locations	Maximum	0.090	0.060	0.034	0.052	0.129	0.409	0.063	0.016	0.030
	99th	0.030	0.025	0.034	0.017	0.025	0.117	0.012	0.004	0.026
	95th	0.011	0.011	0.017	0.006	0.010	0.018	0.006	0.002	0.013
	90th	0.008	0.004	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	80th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	14.0%	8.4%	0.0%	1.4%	3.5%	5.5%	0.8%	0.0%	0.2%
Agriculture										
Agriculture	Maximum	0.090	0.055	0.034	0.039	0.025	0.409	0.063	0.004	0.026
	99th	0.032	0.015	0.034	0.028	0.017	0.127	0.012	0.004	0.026
	95th	0.011	0.004	0.017	0.006	0.009	0.073	0.006	0.002	0.013
	90th	0.008	0.002	0.017	0.003	0.005	0.002	0.006	0.002	0.013
	80th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	17.6%	5.3%	0.0%	2.4%	3.3%	9.1%	0.8%	0.0%	0.0%

Land Use	Value	chlorpyrifos	diazinon	disulfoton	ethoprop	malathion	azinphos methyl	methyl parathion	phorate	terbufos
Concentration (ug/L)										
Urban	Maximum	0.047	0.060	0.034	0.052	0.129	0.044	0.041	0.016	0.026
	99th	0.024	0.034	0.033	0.016	0.04016	0.04214	0.040	0.004	0.025
	95th	0.014	0.021	0.017	0.003	0.013	0.001	0.006	0.002	0.013
	90th	0.010	0.013	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	80th	0.004	0.005	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	16.5%	18.3%	0.0%	0.9%	8.3%	1.9%	1.8%	0.0%	0.0%
Mixed	Maximum	0.082	0.051	0.034	0.006	0.027	0.220	0.012	0.011	0.030
	99th	0.033	0.017	0.034	0.006	0.027	0.096	0.012	0.011	0.027
	95th	0.010	0.005	0.034	0.006	0.010	0.050	0.012	0.004	0.026
	90th	0.008	0.004	0.021	0.005	0.010	0.002	0.006	0.004	0.017
	80th	0.005	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	8.1%	8.1%	0.0%	0.0%	0.0%	2.6%	0.0%	0.0%	1.2%
Long Island/ New Jersey										
All Locations	Maximum	0.064	0.300	0.021	0.005	0.078	0.039	0.006	0.011	0.033
	99th	0.038	0.211	0.021	0.005	0.027	0.039	0.006	0.011	0.017
	95th	0.019	0.089	0.017	0.004	0.025	0.027	0.006	0.002	0.017
	90th	0.010	0.048	0.017	0.003	0.006	0.001	0.006	0.002	0.013
	80th	0.005	0.020	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.005	0.015	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.003	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	24.6%	52.6%	0.0%	0.0%	7.6%	1.2%	0.0%	0.0%	0.4%
Agricultural	Maximum	0.030	0.008	0.017	0.003	0.012	0.001	0.006	0.002	0.013
	99th	0.027	0.008	0.017	0.003	0.012	0.001	0.006	0.002	0.013
	95th	0.014	0.006	0.017	0.003	0.010	0.001	0.006	0.002	0.013
	90th	0.004	0.005	0.017	0.003	0.008	0.001	0.006	0.002	0.013
	80th	0.004	0.004	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.004	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	0.0%	38.5%	0.0%	0.0%	15.4%	0.0%	0.0%	0.0%	0.0%
Urban	Maximum	0.064	0.300	0.021	0.005	0.078	0.039	0.006	0.011	0.033
	99th	0.040	0.232	0.021	0.005	0.027	0.039	0.006	0.011	0.018
	95th	0.021	0.113	0.017	0.003	0.020	0.007	0.006	0.002	0.013
	90th	0.015	0.060	0.017	0.003	0.010	0.001	0.006	0.002	0.013
	80th	0.008	0.028	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.005	0.020	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.004	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	32.6%	59.1%	0.0%	0.0%	11.4%	2.3%	0.0%	0.0%	0.8%

Land Use	Value	chlorpyrifos	diazinon	disulfoton	ethoprop	malathion	azinphos methyl	methyl parathion	phorate	terbufos
		Concentration (ug/L)								
Mixed	Maximum	0.040	0.103	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	99th	0.037	0.101	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	95th	0.009	0.070	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	90th	0.007	0.043	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	80th	0.005	0.025	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.005	0.020	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.006	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	16.4%	60.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Hudson River Basin										
All Locations	Maximum	0.060	0.697	0.021	0.005	0.130	0.05	0.006	0.011	0.017
	99th	0.017	0.130	0.021	0.005	0.027	0.05	0.006	0.011	0.017
	95th	0.005	0.052	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	90th	0.004	0.032	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	80th	0.004	0.010	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.007	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	2.5%	28.2%	0.0%	0.0%	1.2%	0.0%	0.0%	0.0%	0.0%
Agricultural Cropland	Maximum	0.024	0.697	0.021	0.005	0.027	0.05	0.006	0.011	0.017
	99th	0.013	0.054	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	95th	0.004	0.021	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	90th	0.004	0.007	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	80th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	1.3%	10.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Urban Residential	Maximum	0.060	0.550	0.021	0.005	0.13	0.05	0.006	0.011	0.017
	99th	0.016	0.237	0.021	0.005	0.0979	0.05	0.006	0.011	0.017
	95th	0.005	0.119	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	90th	0.005	0.076	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	80th	0.004	0.045	0.017	0.003	0.015	0.001	0.006	0.002	0.013
	75th	0.004	0.039	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.015	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	4.8%	60.6%	0.0%	0.0%	5.8%	0.0%	0.0%	0.0%	0.0%
Mixed	Maximum	0.024	0.093	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	99th	0.017	0.064	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	95th	0.005	0.028	0.017	0.003	0.011	0.002	0.006	0.002	0.013
	90th	0.004	0.014	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	80th	0.004	0.008	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.007	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013

Land Use	Value	chlorpyrifos	diazinon	disulfoton	ethoprop	malathion	azinphos methyl	methyl parathion	phorate	terbufos
		Concentration (ug/L)								
	Frequency	2.9%	34.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Delmarva Peninsula (1999-2001)										
All Locations	Maximum det	0.014	0.005	0.021	0.005	0.034	0.05	0.006	0.011	0.017
	99th	0.009	0.005	0.021	0.005	0.029	0.05	0.006	0.011	0.017
	95th	0.005	0.005	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	90th	0.005	0.005	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	80th	0.005	0.005	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	75th	0.005	0.004	0.017	0.003	0.012	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	17.1%	7.9%	0.0%	0.0%	2.6%	0.0%	0.0%	0.0%	0.0%

e. Region E: Humid Southeast

Only acephate and terbufos (total residues) had estimated maximum concentrations greater than 1 ppb (Table III.E.1-12). Terbufos, acephate, phorate, and disulfoton contributed to the peak OP cumulative loads in water. More detailed discussion and analysis of the OP load in drinking water sources can be found in section II.E.

Table II.E.6. Predicted percentile concentrations of individual OP pesticides and of OP cumulative distribution, Southeast Region.

Chemical	Crop/Use	Concentration ug/L (ppb)						
		Max	99th	95th	90th	80th	75th	50th
Acephate	Cotton, Peanut, Tobacco	1.7e+00	4.3e-02	3.1e-03	7.0e-04	2.1e-05	1.8e-06	1.7e-08
Chlorpyrifos	Corn, Peanut, Tobacco	2.6e-01	9.9e-02	5.6e-02	3.8e-02	2.2e-02	1.8e-02	5.8e-03
Dimethoate	Cotton	7.4e-02	1.2e-02	2.7e-03	1.0e-03	2.3e-04	7.7e-05	9.1e-07
Disulfoton (total residues)	Cotton	4.3e-02	2.8e-02	1.6e-02	1.2e-02	7.8e-03	6.5e-03	3.4e-03
Ethoprop	Tobacco	2.2e-01	1.4e-01	4.8e-02	2.9e-02	1.5e-02	1.2e-02	4.9e-03
Methamidophos	Acephate degradate	2.1e-01	5.2e-03	1.7e-04	9.8e-06	4.5e-08	1.4e-08	4.2e-10
Phorate (total residues)	Cotton, Peanut	6.6e-01	3.9e-02	1.7e-03	4.7e-05	2.1e-09	1.4e-11	1.0e-12
Terbufos (total residues)	Corn	1.5e+00	4.0e-01	1.1e-01	3.9e-02	6.5e-03	1.6e-03	1.2e-04
Tribufos	Cotton	2.4e-02	1.6e-02	1.1e-02	9.6e-03	7.8e-03	7.3e-03	5.4e-03
OP Cumulative Concentration in Methamidophos Equivalents		3.8e+00	1.1e+00	3.6e-01	1.6e-01	6.5e-02	4.9e-02	1.8e-02

i. Comparison of Monitoring Data versus Model Estimates

The Albemarle-Pamlico Drainage Basin (ALBE) NAWQA study unit, located primarily in the Piedmont and Coastal Plain physiographic provinces of southeastern Virginia and northeastern North Carolina, includes the area identified as a vulnerable watershed for the OP cumulative assessment. The NAWQA study included chlorpyrifos, disulfoton, ethoprop, phorate, and terbufos in its monitoring program.

Chlorpyrifos was detected in 14% of agricultural streams, at a maximum of 0.058 ug/l, roughly equivalent to the estimated 95th percentile concentration. The estimated concentrations and measured concentrations in the ALBE agricultural streams were within a factor of 10 of each other at the 90th and greater percentiles. Ethoprop was detected in 4% of all samples, with a maximum detection of 0.8 ug/l in an agricultural stream, greater than the estimated peak of 0.2 ug/l. Phorate was detected in little more than 1% of samples, with a maximum concentrations of about 0.03 ug/l, roughly equivalent to the 99th percentile estimated concentration. Terbufos was detected in a single mixed land-use sample at 0.01 ug/l, slightly less than the 90th percentile estimated concentration.

For chlorpyrifos, both estimated and observed concentrations in Chicod Creek were consistent except for the 80th percentile and higher, at which the estimated values dramatically increased (Figure III.E.1-9). Ethoprop, another contributor chemical, was only detected once in Chicod Creek.

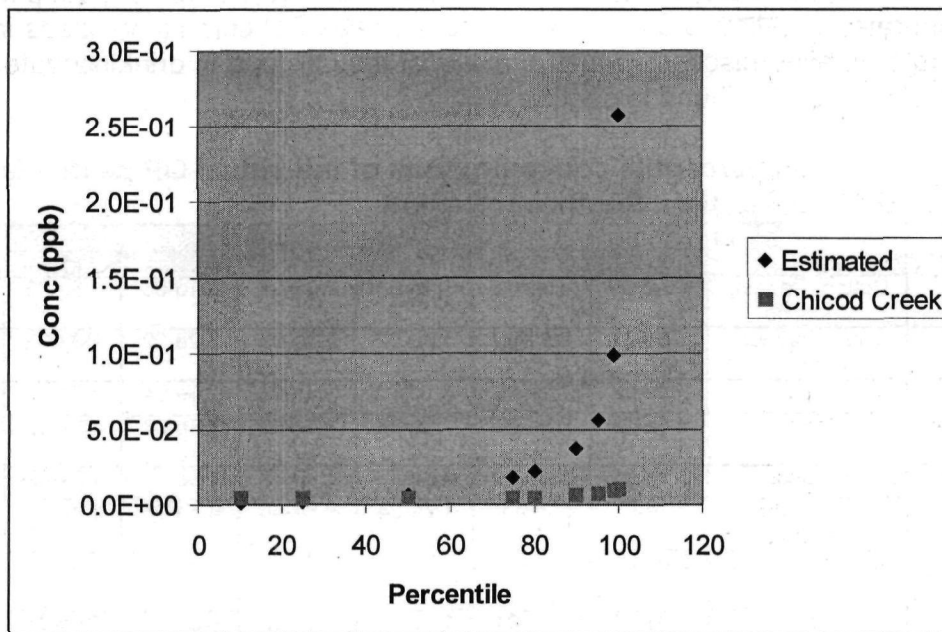


Figure III.E.1-9. Comparison of observed and estimated chlorpyrifos concentrations in the Humid Southeast Region.

ii. Summary of NAWQA Monitoring Data in the Region

The **Albemarle-Pamlico Drainage Basin (ALBE)** NAWQA study unit is located primarily in the Piedmont and Coastal Plain physiographic provinces of southeastern Virginia and northeastern North Carolina. Nearly equivalent portions of the population derived drinking water from surface water and ground water in 1990, with one-third of the population drawing water from domestic wells.

Shallow wells (< 50 feet) in unconsolidated surficial aquifers were sampled because they were most likely to be vulnerable to contamination. Several public supply wells were also included to see if pumping drew contamination from the surficial wells. Diazinon was detected in 7% of ground-water samples, and chlorpyrifos in a single ground-water sample. The USGS Circular 1157 indicates that both were detected in the agricultural (corn-soybean) land-use study, but does not indicate whether some of the diazinon detections occurred in the Virginia Beach urban land-use study. The maximum concentration of diazinon in ground water was about 0.1 ug/l. The single detection of chlorpyrifos was <0.01 ug/l.

Diazinon (9.5%) and chlorpyrifos (13.9%) were the OPs most frequently detected in agricultural streams, although both were more often detected in

mixed land-use streams. Diazinon was detected at a maximum concentration of 0.11 ug/l in these streams, and chlorpyrifos at a maximum of 0.058 ug/l. Malathion was detected in 7.7% of all samples, with a maximum detection of 0.055 ug/l. Ethoprop was detected in 4.4% of all samples, with a maximum detection of 0.8 ug/l in an agricultural stream. Phorate and azinphos methyl were detected in little more than 1% of samples each, with maximum concentrations of about 0.03 ug/l. Terbufos was detected in a single mixed land-use sample at 0.01 ug/l. Surface water was collected at four intensive sampling sites, and 66 other stream sites sampled one to six times in the study.

The **Apalachicola-Chattahoochee-Flint River Basin (ACFB) NAWQA** study site extends from north of Atlanta along the Georgia-Alabama border through the Florida panhandle to the Gulf of Mexico. The northern portion of the study unit is in the Piedmont physiographic province, and the southern portion in the Coastal Plain. Ninety-three percent of the population in the Piedmont derived drinking water from surface water in 1990, while surface water and ground water served nearly equivalent populations in the Coastal Plain. Nearly half of the ground water in the basin was supplied by the vulnerable, karst limestone, Upper Floridan aquifer.

Pesticides were most frequently detected in the karst recharge areas of the Upper Floridan aquifer, but OPs were rarely detected. USGS Circular 1164 indicates that chlorpyrifos and terbufos were both detected once at about 0.01 µg/l, but the dataset available on the study unit world wide web page does not include these detections. Diazinon was detected twice in the urban land-use study. Malathion was detected once in the agricultural land-use study at a concentration of 0.011 µg/l.

Diazinon, chlorpyrifos and malathion were frequently detected in this study unit, but almost exclusively in urban or suburban stream samples. Malathion was detected in an urban stream with a maximum concentration of 0.14 µg/l. Ethoprop was detected twice in urban or suburban streams, and once in an agricultural stream (maximum concentration 0.021 µg/l). Azinphos-methyl, disulfoton and terbufos were detected once each in urban or suburban streams, at concentrations of 0.018 µg/l or less.

The **Potomac River Basin (POTO) NAWQA** study unit is comprised of parts of Virginia, West Virginia, Maryland, Pennsylvania and the District of Columbia. Surface water is the dominant source of drinking water in this basin, although nearly 800,000 people in the basin relied on domestic wells in 1990.

Surface-water sites included for intensive sites sampled 24 times a year for two years in agricultural and urban areas. Twenty-three tributaries with watersheds of greater than 100 square miles were sampled once each, and 25 to 39 tributaries with smaller basins were sampled once each for three

years. Diazinon was the most detected OP, found in 24% of samples, with a maximum concentration of 1.4 ug/l. Chlorpyrifos was detected in 8% of samples, with a maximum concentration of 0.041 ug/l. Methyl parathion was detected in 2% of samples, but some portion of these detections might be due to since-cancelled orchard uses. Malathion, ethoprop and azinphos methyl were also detected in fewer than 5% of samples.

Ground-water was sampled one time from each of 48 wells in the Piedmont and physiographic province from the Washington DC metropolitan area through central Maryland. Another 54 agricultural and 3 forest region wells were sampled once each to the west in the Valley and Ridge physiographic region. Chlorpyrifos is described as an important agricultural chemical in the Potomac River Basin, with use on corn, alfalfa and apples. It was detected in two ground-water samples, with a maximum concentration of about 0.05 ug/l. Diazinon was detected in ground water three times, with a maximum concentration of about 0.01 ug/l, and malathion once at <0.005 ug/l. Neither is listed as a major agricultural chemical in the region.

The **Santee River Basin and Coastal Drainages (SANT) NAWQA** study unit includes much of South Carolina, and extends into southwestern North Carolina. Eighty-six percent of drinking water in this region is from rivers and reservoirs, although rural regions which are not on public supply rely on domestic wells. In the north of the study unit, the relatively undeveloped land in the Blue Ridge physiographic province has little affect on water quality. However, development is more extensive in the Piedmont, and the rivers which provide drinking water are well-regulated, as 85% of water use is for the production of energy. Toward the coast, slow-moving rivers in the Coastal Plain run through marshland and row-crop farmland.

Analysis for pesticides was included in intensive (3 sites) and fixed-site (13 sites) surface water studies over a range of land uses, and at 16 urban sampling sites. Chlorpyrifos, diazinon and malathion were the only OPs detected more than once. All three were detected in more than half of urban samples, but only chlorpyrifos (60%) was detected in more than 10 % of agricultural samples. Chlorpyrifos was detected at a maximum concentration of 0.03 µg/l in an agricultural stream, and malathion at 0.216 in an urban stream. Methyl parathion was detected once in an urban stream at 0.013 µg/l.

Diazinon was detected in a single agricultural well at around 0.005 µg/l, and in a well from the Sandhills aquifer at about 0.06 µg/l. Chlorpyrifos and diazinon were detected in 2 and 3 urban wells, respectively. No other OPs were detected in ground water.

Table III.E.1-13. Magnitude and Frequency of Occurrence of OP Pesticides Analyzed in the NAWQA Study Units in the Southern Seaboard Portion of the Humid Southeast Region.

Land Use	Value	chlorpyrifos	diazinon	disulfoton	ethionop	malathion	azinphos methyl	methy parathion	phorate	terbufos
Concentration (ug/L)										
Albemarle										
All Locations	Maximum	0.058	0.110	0.021	0.800	0.067	0.031	0.020	0.033	0.01
	99th	0.020	0.066	0.021	0.013	0.044	0.031	0.006	0.024	0.017
	95th	0.008	0.013	0.017	0.005	0.021	0.020	0.006	0.010	0.013
	90th	0.005	0.009	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	80th	0.004	0.005	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.004	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	14.6%	28.1%	0.0%	4.4%	7.7%	1.1%	0.0%	1.4%	0.3%
Agriculture	Maximum	0.058	0.110	0.017	0.800	0.055	0.013	0.006	0.019	0.013
	99th	0.034	0.073	0.017	0.021	0.010	0.001	0.006	0.019	0.013
	95th	0.009	0.008	0.017	0.003	0.005	0.001	0.006	0.010	0.013
	90th	0.006	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	80th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	13.9%	9.5%	0.0%	5.0%	3.0%	1.0%	0.0%	2.0%	0.0%
Mixed	Maximum	0.030	0.110	0.021	0.014	0.067	0.031	0.020	0.033	0.01
	99th	0.012	0.044	0.021	0.010	0.046	0.031	0.006	0.011	0.017
	95th	0.007	0.018	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	90th	0.005	0.012	0.017	0.005	0.023	0.024	0.006	0.002	0.013
	80th	0.004	0.008	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.007	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.003	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	16.3%	54.2%	0.0%	3.9%	13.7%	1.3%	0.0%	0.7%	0.7%
Santee River										
All Locations	Maximum	0.095	0.323	0.021	0.005	0.216	0.039	0.013	0.011	0.017
	99th	0.062	0.116	0.021	0.005	0.097	0.039	0.006	0.011	0.017
	95th	0.022	0.031	0.021	0.005	0.029	0.050	0.006	0.011	0.017
	90th	0.014	0.020	0.017	0.003	0.027	0.001	0.006	0.002	0.013
	80th	0.007	0.008	0.017	0.003	0.008	0.001	0.006	0.002	0.013
	75th	0.006	0.005	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	39.9%	24.3%	0.0%	0.0%	15.9%	0.0%	0.4%	0.0%	0.0%
Agriculture	Maximum	0.030	0.008	0.017	0.003	0.012	0.001	0.006	0.002	0.013
	99th	0.027	0.008	0.017	0.003	0.012	0.001	0.006	0.002	0.013
	95th	0.014	0.006	0.017	0.003	0.010	0.001	0.006	0.002	0.013
	90th	0.004	0.005	0.017	0.003	0.008	0.001	0.006	0.002	0.013

Land Use	Value	chlorpyrifos	diazinon	disulfoton	ethoprop	malathion	azinphos methyl	methyl parathion	phorate	terbufos
		Concentration (ug/L)								
	80th	0.004	0.004	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.004	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	0.0%	38.5%	0.0%	0.0%	15.4%	0.0%	0.0%	0.0%	0.0%
Forest	Maximum	0.007	0.015	0.017	0.003	0.018	0.001	0.006	0.002	0.013
	99th	0.006	0.010	0.017	0.003	0.01306	0.001	0.006	0.002	0.013
	95th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	90th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	80th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	2.6%	2.6%	0.0%	0.0%	2.6%	0.0%	0.0%	0.0%	0.0%
Urban	Maximum	0.095	0.323	0.021	0.005	0.216	0.05	0.0125	0.011	0.017
	99th	0.084	0.298	0.021	0.005	0.18518	0.05	0.008	0.011	0.017
	95th	0.022	0.102	0.021	0.005	0.089	0.050	0.006	0.011	0.017
	90th	0.015	0.048	0.017	0.003	0.059	0.001	0.006	0.002	0.013
	80th	0.011	0.032	0.017	0.003	0.028	0.001	0.006	0.002	0.013
	75th	0.010	0.030	0.017	0.003	0.027	0.001	0.006	0.002	0.013
	50th	0.005	0.018	0.017	0.003	0.008	0.001	0.006	0.002	0.013
	Frequency	67.6%	80.9%	0.0%	0.0%	48.5%	0.0%	1.5%	0.0%	0.0%
Mixed	Maximum	0.006	0.015	0.021	0.005	0.0886	0.050	0.006	0.011	0.017
	99th	0.005	0.011	0.021	0.005	0.049	0.050	0.006	0.011	0.017
	95th	0.005	0.005	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	90th	0.005	0.005	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	80th	0.004	0.004	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	1.5%	7.7%	0.0%	0.0%	6.2%	0.0%	0.0%	0.0%	0.0%
All Locations	Maximum	0.170	2.800	0.018	0.021	0.140	0.11	0.006	0.011	0.017
	99th	0.059	0.255	0.021	0.005	0.045	0.05	0.006	0.011	0.017
	95th	0.016	0.063	0.017	0.005	0.027	0.050	0.006	0.002	0.013
	90th	0.011	0.032	0.017	0.003	0.009	0.001	0.006	0.002	0.013
	80th	0.005	0.016	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.005	0.012	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	25.6%	46.5%	0.2%	0.5%	6.7%	0.2%	0.0%	0.0%	0.2%
Agricultural Cropland	Maximum	0.099	0.012	0.021	0.010	0.009	0.05	0.006	0.011	0.017
	99th	0.005	0.005	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	95th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	90th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013

Land Use	Value	chlorpyrifos	diazinon	disulfoton	ethoprop	malathion	azinphos methyl	methy/parathion	phorate	terbufos
		concentration (ug/l)								
	80th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	0.6%	0.6%	0.0%	0.6%	1.3%	0.0%	0.0%	0.0%	0.0%
Urban Residential	Maximum	0.170	2.800	0.018	0.021	0.14	0.11	0.006	0.011	0.017
	99th	0.085	0.366	0.021	0.008	0.06669	0.05	0.006	0.011	0.017
	95th	0.040	0.124	0.017	0.003	0.027	0.001	0.006	0.002	0.013
	90th	0.020	0.067	0.017	0.003	0.017	0.001	0.006	0.002	0.013
	80th	0.011	0.033	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.010	0.029	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.011	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	50.0%	81.9%	0.4%	0.9%	11.6%	0.4%	0.0%	0.0%	0.4%
Mixed	Maximum	0.018	0.103	0.021	0.005	0.044	0.300	0.006	0.011	0.017
	99th	0.014	0.063	0.021	0.005	0.035	0.070	0.006	0.011	0.017
	95th	0.010	0.029	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	90th	0.008	0.019	0.017	0.003	0.016	0.001	0.006	0.002	0.013
	80th	0.005	0.013	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.005	0.012	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.005	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	21.8%	52.8%	0.0%	0.0%	6.3%	0.0%	0.0%	0.0%	0.0%
Georgia portion of GA-FL coastal Plain										
All Locations	Maximum	0.028	0.097	0.021	0.018	0.226	0.166	0.200	0.003	0.018
	99th	0.017	0.068	0.021	0.010	0.027	0.073	0.006	0.011	0.017
	95th	0.007	0.010	0.017	0.005	0.026	0.050	0.006	0.002	0.013
	90th	0.005	0.005	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	80th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	8.9%	11.6%	0.3%	4.0%	5.2%	0.6%	0.0%	0.3%	0.3%
Agricultural	Maximum	0.021	0.025	0.021	0.018	0.025	0.166	0.200	0.003	0.018
	99th	0.014	0.007	0.021	0.009	0.025	0.079	0.006	0.011	0.017
	95th	0.006	0.002	0.017	0.005	0.007	0.001	0.006	0.002	0.013
	90th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	80th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	6.7%	1.4%	0.5%	3.3%	2.9%	1.0%	0.0%	0.5%	0.5%
Mixed	Maximum	0.028	0.097	0.021	0.015	0.226	0.3	0.050	0.020	0.017
	99th	0.018	0.087	0.021	0.012	0.033	0.05	0.032	0.011	0.017
	95th	0.008	0.026	0.021	0.006	0.027	0.050	0.006	0.011	0.017

Land Use	Value	chlorpyrifos	diazinon	disulfoton	ethoprop	malathion	azinphos methyl	methyl parathion	phorate	terbufos
		Concentration (ug/L)								
	90th	0.006	0.011	0.017	0.005	0.017	0.001	0.006	0.002	0.013
	80th	0.004	0.007	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.006	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	13.5%	31.5%	0.0%	5.4%	9.9%	0.0%	0.0%	0.0%	0.0%

The **NAWQA Upper Tennessee River Basin (UTEN)** study unit includes Henderson County, North Carolina, the OP high-use area chosen for the Eastern Uplands surface-water modeling. The study area is located primarily in western North Carolina, eastern Tennessee, and southwest Virginia. Sampling in this study occurred between 1995 and 1999, and included nine of the OP insecticides that are part of the cumulative water assessment.

Surface-water monitoring was concentrated in the unregulated portions of the Tennessee River, which is extensively dammed for generation of hydroelectric power. Chlorpyrifos (10% of samples), diazinon (12%) and malathion are the only OPs detected in 428 samples taken biweekly between March and November, 1996. The maximum concentration of diazinon reported was 0.59 ug/l. The frequency of detection for diazinon was greater for sampling locations identified as "mixed land use" while the frequency of detection for chlorpyrifos was greater from "agricultural" sampling sites.

No OPs were detected in ground-water sampling for the Upper Tennessee River (UTEN) NAWQA study. Thirty monitoring wells were located next to tobacco fields, while 30 additional wells and 35 springs were randomly selected from around the Valley and Ridge portion of the study site. Each well or spring was sampled a single time. Domestic wells are the main source of drinking water for one-third of the population in the UTEN study region.

The **Kanawha-New River Basin (KANA)** NAWQA study site, located primarily in south-central West Virginia and southwest Virginia, represents a less agricultural region with less OP use. Chlorpyrifos, diazinon and malathion were detected in the KANA study. Diazinon and malathion were detected in surface water.

Chlorpyrifos was detected in one of 60 domestic or supply wells in the Kanawha-New River (KANA) NAWQA study at a concentration of 0.004 ppb. Thirty of the wells were located in the mountainous coal-mining Appalachian Plateau physiographic province in West Virginia. Chlorpyrifos was detected in a well in the relatively more agricultural Blue Ridge physiographic province, in the southern portion of the study unit. Domestic wells are reported to supply drinking water to thirty percent of the population in the KANA study unit.

The **Allegheny and Monongahela River Basins (ALMN)** study unit is located in northeastern West Virginia and western Pennsylvania. Agriculture

accounts for only 30% of land use in the study unit, "commonly low-intensity pasture, dairy and hay." Diazinon and chlorpyrifos are the only active OPs detected in this monitoring program. Diazinon was detected at two of 18 agricultural stream samples, and in seven of 26 (31%) urban stream samples, with maximum concentrations of about 0.1 ug/l. Chlorpyrifos is also reported as having been detected in surface water. Surface water is the main source of drinking water in the Pittsburgh region.

Diazinon was also detected in ground water in six of 58 samples from major aquifers in the Allegheny-Monongahela River (ALMN) NAWQA study, with a maximum concentration of 0.007 ppb. Domestic wells are reported by the USGS as the major source of drinking water for people living in rural areas of the ALMN study unit.

Table III.E.1-14. Magnitude and Frequency of Occurrence of OP Pesticides Analyzed in the NAWQA Study Units in the Eastern Uplands Portion of the Humid Southeast Region.

Land Use	Value	chlorpyrifos	diazinon	disulfoton	ethoprop	malathion	azinphos methyl	methy parathion	phorate	terbufos
Concentration, ug/L										
Upper Tennessee River Basin										
All Locations	Maximum	0.033	0.590 ¹	<0.021	0.018	0.046 ¹	0.0386	<0.006	<0.011	<0.017
	95th	0.005	0.005	<0.017	<0.003	<0.005	<0.050	<0.006	<0.002	<0.013
	90th	0.005	0.004	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	75th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	Frequency	10.1%	12.1%	0.0%	0.4%	1.4%	0.2%	0.0%	0.0%	0.0%
Agriculture	Maximum	0.033	0.006	<0.021	<0.005	0.015	<0.11	<0.006	<0.011	<0.017
	95th	0.006	0.004	<0.017	<0.003	<0.008	<0.050	<0.006	<0.002	<0.013
	90th	0.005	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	75th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	Frequency	13.2%	3.9%	0.0%	0.0%	2.0%	0.0%	0.0%	0.0%	0.0%
Forestry	Maximum	0.012	0.066	<0.021	0.018	0.015	0.0386	<0.006	0.011	0.017
	95th	0.005	0.008	<0.021	<0.005	<0.027	<0.050	<0.006	<0.011	<0.017
	90th	<0.005	0.005	<0.017	<0.003	<0.005	<0.005	<0.006	<0.002	<0.013
	75th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	Frequency	5.0%	16.3%	0.0%	1.3%	1.3%	1.3%	0.0%	0.0%	0.0%
Mixed	Maximum	0.014	0.040	<0.021	0.015	0.0061	<0.700	<0.006	<0.011	<0.017
	95th	0.005	0.005	<0.017	<0.003	<0.005	<0.200	<0.006	<0.002	<0.013
	90th	<0.004	0.005	<0.017	<0.003	<0.005	<0.034	<0.006	<0.002	<0.013
	75th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	Frequency	8.6%	14.8%	0.0%	0.5%	0.5%	0.0%	0.0%	0.0%	0.0%
(1) The maximum concentrations of diazinon and malathion occurred at a sample site located in a watershed influenced by mining. Sample sites representing watersheds with mining land uses were not broken out separately in this summary table.										
Kanawha-New River Basin										
All Locations	Maximum	0.004	0.004	<0.017	<0.003	0.005	<0.06	<0.006	<0.002	<0.013
	95th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	90th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013

Land Use	Value	chlor-pyrifos	diazinon	disulfoton	ethoprop	malathion	azinphos methyl	methyl parathion	phorate	terbufos
Concentration, ug/L										
	75th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	Frequency	4.4%	1.5%	0.0%	0.0%	1.5%	0.0%	0.0%	0.0%	0.0%
NOTE: Because of the low number of samples (68 samples were analyzed for OPs) and the low frequency of detects, monitoring data for this study unit were not broken down by land use within the watershed.										
Allegheny and Monongahela River Basin										
All	Maximum	0.010	0.097	<0.017	<0.003	<0.020	0.033	<0.006	<0.002	<0.013
Locations	95th	<0.004	0.027	<0.017	<0.003	<0.005	<0.010	<0.006	<0.002	<0.013
	90th	<0.004	0.013	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	75th	<0.004	0.003	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	Frequency	7.4%	27.2%	0.0%	0.0%	0.0%	1.2%	0.0%	0.0%	0.0%
Agriculture	Maximum	0.010	0.094	<0.017	<0.003	<0.005	0.033	<0.006	<0.002	<0.013
	95th	0.009	0.016	<0.017	<0.003	<0.005	<0.220	<0.006	<0.002	<0.013
	90th	0.005	0.003	<0.017	<0.003	<0.005	<0.066	<0.006	<0.002	<0.013
	75th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	Frequency	21.1%	10.5%	0.0%	0.0%	0.0%	5.3%	0.0%	0.0%	0.0%
Urban	Maximum	<0.004	0.097	<0.017	<0.003	<0.005	<0.8	<0.006	<0.002	<0.013
	95th	<0.004	0.051	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	90th	<0.004	0.027	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	75th	<0.004	0.013	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	Frequency	6.5%	35.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Mixed	Maximum	<0.004	0.010	<0.017	<0.003	<0.02	<0.010	<0.006	<0.002	<0.013
	95th	<0.004	0.006	<0.017	<0.003	<0.010	<0.006	<0.006	<0.002	<0.013
	90th	<0.004	0.005	<0.017	<0.003	<0.010	<0.001	<0.006	<0.002	<0.013
	75th	<0.004	<0.002	<0.017	<0.003	<0.005	<0.001	<0.006	<0.002	<0.013
	Frequency	0.0%	23.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

f. Region F: Lower Midwest

Estimated maximum concentrations of malathion and terbufos (parent plus sulfoxide/sulfone) were in the single parts per billion (Table III.E.1-15). More detailed discussion and analysis of the OP load in drinking water sources can be found in section II.F.

Table III.E.1-15. Predicted percentile concentrations of individual OP pesticides and of the cumulative OP distribution, Lower Midwest Region

Chemical	Crop/Use	Concentrations in ug/L (ppb)						
		Max	99th	95th	90th	80th	75th	50th
Acephate	Cotton	1.4e-01	1.2e-02	1.0e-03	1.9e-04	2.0e-06	1.0e-07	1.1e-09
Chlorpyrifos	Alfalfa, Corn, Cotton, Sorghum	1.3e-01	5.9e-02	2.9e-02	1.8e-02	1.8e-02	8.4e-03	3.5e-03
Dicrctophos	Cotton	3.9e-02	7.9e-03	2.4e-03	9.3e-04	9.3e-04	6.7e-05	2.6e-06
Dimethoate	Corn, Cotton, Wheat	6.5e-02	2.1e-02	7.0e-03	4.1e-03	4.1e-03	1.6e-03	3.3e-04
Malathion	Cotton	1.5e+00	8.2e-02	3.4e-02	1.5e-02	1.5e-02	1.8e-03	6.1e-06
Methamidophos	Acephate degradate	4.6e-02	8.5e-04	3.1e-05	1.1e-06	1.1e-06	3.1e-10	1.4e-11
MethylParathion	Alfalfa, Cotton	6.8e-02	1.5e-02	4.4e-03	2.4e-03	2.4e-03	5.3e-04	3.3e-05
Phorate	Cotton	4.2e-02	3.8e-03	1.2e-04	2.0e-06	2.0e-06	1.7e-11	2.0e-13
Phostebupirim	Corn	6.9e-02	3.2e-02	1.4e-02	8.9e-03	8.9e-03	3.7e-03	1.4e-03
Terbufos	Corn	1.4e+00	4.9e-01	1.7e-01	7.9e-02	7.9e-02	8.6e-03	4.4e-04
Tribufos	Cotton	6.1e-02	3.6e-02	2.3e-02	1.9e-02	1.9e-02	1.3e-02	9.4e-03
OP cumulative in methamidophos equivalents		3.7e+00	1.3e+00	4.8e-01	2.3e-01	5.7e-02	3.0e-02	4.6e-03

i. Comparison of Monitoring Data versus Model Estimates

A comparison of estimated concentrations for individual OP pesticides with NAWQA monitoring indicate that, except for terbufos, NAWQA sites in the Trinity River Basin had higher detections than were predicted for this regional assessment. For methyl parathion, the highest monitoring detect was an order of magnitude greater than the estimated maximum concentration. Although in-depth analysis of use has not been made, it is possible that the methyl parathion discrepancies may reflect differences resulting from uses that have been canceled and are not reflected in the modeling. For chlorpyrifos and malathion, the highest monitoring detections were twice as great as the highest estimated concentration. These differences are not great, and may reflect contributions from urban uses. The estimated concentrations for terbufos include parent terbufos plus the sulfoxide and sulfone transformation products while NAWQA only analyzed for the less persistent and less mobile parent.

Although diazinon has been frequently detected in the Trinity River Basin, particularly in urban streams, the latest NASS surveys indicate little or no agricultural uses of diazinon in the Central Hills area. Detections of diazinon in the Trinity River Basin may reflect residential uses which are being

canceled or uses on other crops during the sampling period that are not reflected in current use surveys.

ii. Summary of NAWQA Monitoring Data in the Region

The **Trinity River Basin (TRIN)** study unit is the NAWQA monitoring program closest to the Central Hills of Texas, the high-use area the Agency chose for the PRZM EXAMS surface-water modeling scenario. More than 90% of water in this basin is supplied by surface water, mostly in reservoirs (USGS Circular 1171). Much of the agricultural land is used for grazing cattle.

Diazinon, chlorpyrifos and malathion were detected in 97%, 71% and 32% of urban samples, respectively. The maximum concentration of diazinon in urban samples was 2.3 µg/l. Diazinon was also detected frequently in agricultural samples (46%) and rangeland streams (38.5%), with a maximum detection of 0.16 µg/l. Azinphos-methyl, methyl parathion and disulfoton were detected in less than 3% of agricultural samples. Of these azinphos had the highest maximum concentration, 0.55 µg/l.

Ground-water sampling was done at outcrop areas of the four major aquifers in the study unit; confining units or minor aquifers are present at the surface (outcrop) over more than half of the area of the TRIN. Diazinon was detected in nearly half of the samples drawn from the 24 wells in the Trinity aquifer outcrop. However, half of the wells also had salinity higher than acceptable for potable water. The maximum concentration of diazinon in ground water was about 0.1 µg/l. It is not clear whether these detections were associated with urban or agricultural applications of diazinon.

The **South-Central Texas (SCTX) NAWQA** study unit includes the city of San Antonio. Ground water is the predominant source of drinking water in this area. The water is mostly derived from the Edwards Aquifer, which is one of the most productive in the world. The Edwards aquifer is recharged by surface water where precipitation and streams meet the fractured and faulted Edwards at its outcrop. This hydraulic connection makes stream and river-water quality important for the Edwards aquifer, which supplies about 70% of water withdrawn in the study unit. The Trinity aquifer is locally important in the Hill Country in the north of SCTX, but is generally less productive than the Edwards.

Ground-water monitoring included domestic wells in the area where surface-water and precipitation recharge the Edwards aquifer, public supply wells in the confined part of the Edwards aquifer, and domestic wells from the less permeable Trinity aquifer. Diazinon was the only OP detected, three times in shallow urban ground water, once in a major aquifer sample, each time <0.1 µg/l. No agricultural ground-water samples were collected.

Three surface-water sampling sites were located at urban and agricultural streams. These were sampled weekly to monthly from January, 1997 to March, 1998. Diazinon was detected in 38% of agricultural samples with a maximum concentration of 0.059 ug/l. Chlorpyrifos (max 0.008 ug/l) was detected in 21% of agricultural samples, and malathion in 9% of all samples (max 0.142 ug/l).

In the **Central Nebraska Basins (CNBR) NAWQA** study unit, ground water is the major source of drinking water. The major source of ground water, the Platte River alluvial aquifer, is hydraulically connected with the North Platte River, both through discharge to the river and increased recharge from the river due to pumping from the aquifer. Sampling included single samples from 11 shallow wells installed in this aquifer. No active OP was detected in ground-water in this limited study (fonofos was detected twice).

A second ground-water study included 61 wells installed in two clusters: one in a recharge area in a meadow near corn fields, and another in and north of a public-supply wellfield on Indian Island in the Platte River near Grand Island. The intention was to study land-use effects on shallow ground-water along the flow path. This study was useful in further showing that the alluvial aquifer shows increasing influence from the Platte River from upstream to downstream. While it did measure pesticide concentrations at a wellfield designed to be protected from agricultural ground-water contamination, it was not designed to evaluate acute exposure to pesticides. No OPs were detected in this study.

OPs were included at four fixed surface-water sampling sites on the Platte River and its tributaries. These were located in areas of heavy corn production. All were sampled monthly, but two of these also were sampled more intensively in the spring and summer of 1992 (including 12 weeks of alternate-day sampling). These two were located in the glaciated area in the eastern, downstream portion of the study unit.

Chlorpyrifos, diazinon and malathion were the most frequently detected OPs. Diazinon was detected mostly in urban or mix-use streams, while at least of the detections of the other two occurred in agricultural streams. Chlorpyrifos had the highest single concentration detected of the three in agricultural streams, at 0.13 µg/l. Methyl parathion, azinphos-methyl and terbufos were detected in less than 3% of samples. A detection of 0.27 µg/l terbufos was the highest concentration detected for any OP.

Table III.E.1-16. Magnitude and Frequency of Occurrence of OP Pesticides Analyzed in the NAWQA Study Units in the Lower Midwest Region

Land Use	Value	chlorpyrifos	diazinon	disulfoton	ethion	malathion	azinphos-methyl	methyl parathion	phorate	terbufos
Concentration (µg/L)										
Trinity River Basin										

Land Use	Value	chlorpyrifos	diazinon	disulfoton	ethopro p	malathion	azinphos methyl	methyl parathion	phorate	terbufos
Concentration (ug/L)										
All Locations	Maximum	0.110	2.300	0.05	0.018	0.380	0.55	0.230	0.016	0.018
	99th	0.069	1.186	0.059	0.012	0.144	0.135	0.044	0.011	0.016
	95th	0.033	0.396	0.017	0.003	0.030	0.001	0.006	0.002	0.013
	90th	0.017	0.186	0.017	0.003	0.014	0.001	0.006	0.002	0.013
	80th	0.009	0.061	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.005	0.037	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.008	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	25.7%	61.3%	0.6%	0.0%	9.2%	1.6%	1.6%	0.0%	0.0%
Agriculture	Maximum	0.048	0.160	0.05	0.012	0.038	0.55	0.230	0.011	0.013
	99th	0.012	0.110	0.060	0.012	0.026	0.437	0.044	0.011	0.013
	95th	0.009	0.024	0.017	0.003	0.010	0.001	0.006	0.002	0.013
	90th	0.004	0.016	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	80th	0.004	0.011	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.009	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	9.4%	46.2%	0.6%	0.0%	2.9%	1.8%	2.9%	0.0%	0.0%
Range	Maximum	0.004	0.037	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	99th	0.004	0.036	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	95th	0.004	0.032	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	90th	0.004	0.024	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	80th	0.004	0.008	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.005	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	0.0%	38.5%	7.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Urban	Maximum	0.110	2.300	0.021	0.018	0.38	0.14	0.051	0.016	0.018
	99th	0.089	2.040	0.018	0.017	0.237	0.114	0.050	0.016	0.017
	95th	0.068	1.175	0.017	0.003	0.140	0.053	0.006	0.002	0.013
	90th	0.050	0.665	0.017	0.003	0.068	0.001	0.006	0.002	0.013
	80th	0.032	0.420	0.017	0.003	0.029	0.001	0.006	0.002	0.013
	75th	0.027	0.375	0.017	0.003	0.022	0.001	0.006	0.002	0.013
	50th	0.011	0.140	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	71.2%	97.0%	0.0%	0.0%	31.8%	3.0%	0.0%	0.0%	0.0%
Mixed	Maximum	0.022	0.340	0.021	0.005	0.0339	0.050	0.006	0.011	0.017
	99th	0.020	0.271	0.020	0.004	0.031	0.037	0.006	0.009	0.016
	95th	0.014	0.075	0.017	0.003	0.022	0.001	0.006	0.002	0.013
	90th	0.010	0.072	0.017	0.003	0.009	0.001	0.006	0.002	0.013
	80th	0.005	0.053	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.048	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.030	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	22.2%	92.6%	0.0%	0.0%	11.1%	0.0%	0.0%	0.0%	0.0%
South-Central Texas										
All Locations	Maximum	0.105	0.527	0.0651	0.128	0.142	0.18	0.132	0.083	0.109
	99th	0.010	0.210	0.021	0.008	0.084	0.050	0.006	0.011	0.017
	95th	0.007	0.095	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	90th	0.005	0.063	0.017	0.003	0.012	0.001	0.006	0.002	0.013
	80th	0.004	0.029	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.020	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.005	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	19.2%	56.0%	0.5%	0.5%	9.3%	0.6%	0.5%	0.5%	1.1%

Land Use	Value	chlorpyrifos	diazinon	disulfoton	ethoprop	malathion	azinphos methyl	methyl parathion	phorate	terbufos
Concentration (ug/L)										
Agriculture	Maximum	0.008	0.059	0.017	0.003	0.008	0.001	0.006	0.002	0.013
	99th	0.007	0.047	0.017	0.003	0.007	0.001	0.006	0.002	0.013
	95th	0.006	0.017	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	90th	0.005	0.007	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	80th	0.004	0.005	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.005	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	20.6%	38.2%	0.0%	0.0%	8.8%	0.0%	0.0%	0.0%	2.9%
Range	Maximum	0.005	0.0031	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	99th	0.005	0.0031	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	95th	0.005	0.0031	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	90th	0.005	0.005	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	80th	0.005	0.004	0.019	0.004	0.018	0.030	0.006	0.007	0.015
	75th	0.004	0.003	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	0.0%	7.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Urban	Maximum	0.010	0.527	0.021	0.005	0.107	0.05	0.006	0.011	0.017
	99th	0.010	0.430	0.021	0.005	0.0925	0.05	0.006	0.011	0.017
	95th	0.009	0.176	0.021	0.005	0.029	0.050	0.006	0.011	0.017
	90th	0.006	0.138	0.017	0.003	0.027	0.001	0.006	0.002	0.013
	80th	0.005	0.072	0.017	0.003	0.011	0.001	0.006	0.002	0.013
	75th	0.005	0.069	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.012	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	29.4%	76.5%	0.0%	0.0%	19.6%	0.0%	0.0%	0.0%	0.0%
Mixed	Maximum	0.105	0.159	0.065	0.128	0.142	0.180	0.132	0.083	0.109
	99th	0.028	0.123	0.029	0.041	0.049	0.076	0.030	0.025	0.034
	95th	0.006	0.052	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	90th	0.005	0.040	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	80th	0.004	0.028	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.022	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.008	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	15.9%	59.8%	1.2%	1.2%	4.9%	1.2%	1.2%	1.2%	1.2%
Central Nebraska										
All Locations	Maximum	0.140	0.039	0.021	0.021	0.054	0.0078	0.061	0.019	0.270
	99th	0.109	0.023	0.021	0.005	0.027	0.050	0.025	0.011	0.020
	95th	0.035	0.012	0.021	0.005	0.027	0.050	0.006	0.011	0.017
	90th	0.018	0.006	0.017	0.003	0.007	0.001	0.006	0.002	0.013
	80th	0.005	0.005	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.005	0.004	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	21.6%	23.2%	0.0%	0.0%	6.1%	0.6%	2.8%	0.0%	0.8%
Agriculture	Maximum	0.130	0.014	0.021	0.021	0.054	0.003	0.061	0.019	0.190
	99th	0.109	0.011	0.021	0.007	0.027	0.052	0.055	0.012	0.020
	95th	0.032	0.005	0.017	0.005	0.017	0.040	0.006	0.011	0.017
	90th	0.020	0.005	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	80th	0.007	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.005	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013

Land Use	Value	chlorpyrifos	diazinon	disulfoton	ethoprophos	malathion	azinphos methyl	methyl parathion	phorate	terbufos
		Concentration (ug/L)								
	Frequency	25.9%	8.6%	0.0%	0.0%	5.9%	0.5%	2.7%	0.0%	0.5%
Mixed	Maximum	0.140	0.0394	0.021	0.005	0.0444	0.050	0.028	0.011	0.270
	99th	0.109	0.025334	0.021	0.005	0.029	0.050	0.022	0.011	0.019
	95th	0.047	0.01454	0.017	0.003	0.020	0.001	0.006	0.010	0.013
	90th	0.016	0.009	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	80th	0.005	0.005	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.005	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	17.8%	39.9%	0.0%	0.0%	5.5%	0.0%	3.1%	0.0%	1.2%

g. Region G: Mid-South

Maximum estimated concentrations of acephate, dicrotophos, and terbufos were in the single parts per billion, while the maximum estimated concentration of malathion was greater than 10 ppb (Table III.E.1-17). More detailed discussion and analysis of the OP load in drinking water sources can be found in section II.G.

Table III.E.1-17. Predicted percentile concentrations of individual OP pesticides and of the cumulative OP distribution in the Midsouth Region.

Chemical	Crop/Use	Concentration ug/L (ppb)						
		Max	99th	95th	90th	80th	75th	50th
Acephate	Cotton	4.6e+00	7.4e-01	1.1e-01	2.8e-02	1.6e-03	2.2e-04	3.9e-07
Chlorpyrifos	Corn	3.7e-02	1.6e-02	7.0e-03	3.9e-03	1.8e-03	1.3e-03	5.3e-04
Dicrotophos	Cotton	1.5e+00	6.3e-01	2.9e-01	1.4e-01	4.7e-02	2.7e-02	9.7e-04
Dimethoate	Corn, Cotton	2.1e-01	6.1e-02	1.3e-02	6.3e-03	1.3e-03	4.6e-04	1.0e-05
Disulfoton	Cotton	1.3e-02	1.1e-02	6.4e-03	4.9e-03	3.1e-03	2.7e-03	1.3e-03
Malathion	Cotton	1.4e+01	1.8e+00	4.2e-01	2.5e-01	8.5e-02	5.0e-02	1.5e-03
Methamidophos	Cotton	7.2e-01	8.1e-02	7.7e-03	1.0e-03	1.2e-05	6.8e-07	8.4e-09
Methyl Parathion	Cotton, Soybeans	1.5e-01	8.1e-02	4.4e-02	2.3e-02	1.0e-02	6.7e-03	1.7e-04
Phorate	Cotton	5.6e-01	8.7e-02	4.2e-03	1.1e-04	8.9e-08	1.5e-09	3.6e-15
Profenofos	Cotton	1.8e-01	2.7e-02	3.8e-03	9.7e-04	9.1e-05	3.0e-05	3.3e-07
Phostebupirim	Corn	3.6e-02	1.5e-02	7.3e-03	4.5e-03	2.5e-03	2.1e-03	9.5e-04
Terbufos	Corn	1.0e+00	3.5e-01	1.2e-01	6.8e-02	2.1e-02	1.2e-02	4.9e-04
Tribufos	Cotton	3.3e-01	2.2e-01	1.7e-01	1.2e-01	7.6e-02	6.6e-02	4.4e-02
OP Cumulative Concentration (in ppb methamidophos equivalents)		8.7e+00	4.3e+00	1.9e+00	1.0e+00	4.4e-01	3.1e-01	4.1e-02

i. Comparison of Monitoring Data versus Model Estimates

The maximum detect from the USGS NAWQA Mississippi Embayment study unit for chlorpyrifos was an order of magnitude greater than the maximum estimated concentration. The estimated maximum concentration is roughly equivalent to the 90th percentile concentration in the monitoring data. The maximum detect for methyl parathion in NAWQA was four times greater than the maximum estimated concentration. The estimated peak concentration falls somewhere between the 95th and 99th percentile of monitoring data. The maximum detect for disulfoton in NAWQA was an order of magnitude greater than the estimated maximum concentration, which was less than the analytical limit of detection (LOD) for disulfoton in the USGS study. On the other side, the maximum estimated concentration for malathion was an order of magnitude greater than the highest NAWQA detection, which fell between the 95th and 99th percentile in the estimated distribution.

While dicrotophos was not included in the NAWQA study, it was included in an earlier USGS study on cotton pesticides in the Mississippi Embayment (USGS Fact Sheet 022-98; Thurman et al, 1998. Available from the web site <http://ks.water.usgs.gov/Kansas/pubs/fact-sheets/fs.022-98.html>). Dicrotophos was detected in 35% of the samples (a comparison of the dicrotophos LOD of 0.016 ug/L to the estimated concentration distribution

shows an equivalent percentage above the LOD). The maximum detection reported for dicrotophos corresponds to the estimated 90th to 95th percentiles.

The Bogue Phalia River near Leland, MS contained the most detections and co-occurrences. Malathion, methyl parathion, and chlopyrifos were all detected in the Bogue Phalia River, but chlorpyrifos was only detected twice. For malathion (Figure III.E.1-10), both estimated and observed concentrations were consistent except for the highest percentiles. For methyl parathion (Figure III.E.1-11), the observed concentrations were higher than estimated starting about the 80th percentile.

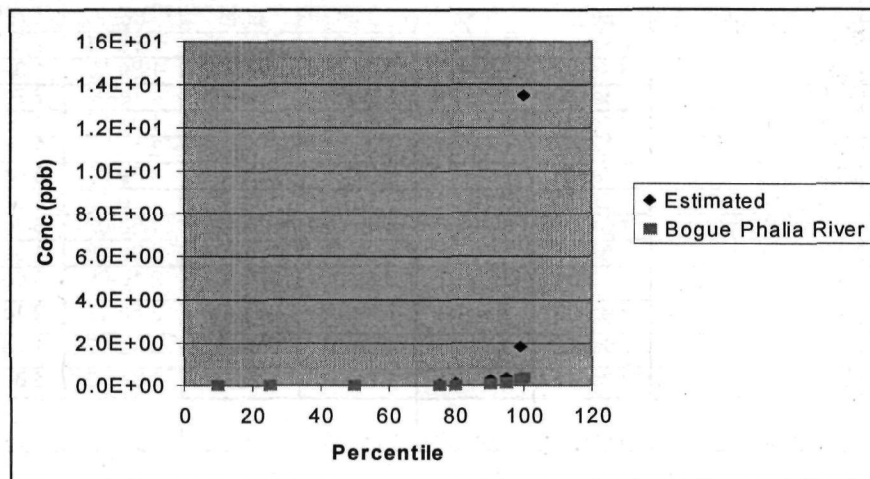


Figure III.E.1-10. Comparison of observed and estimated malathion concentrations in the Mid-South Region.

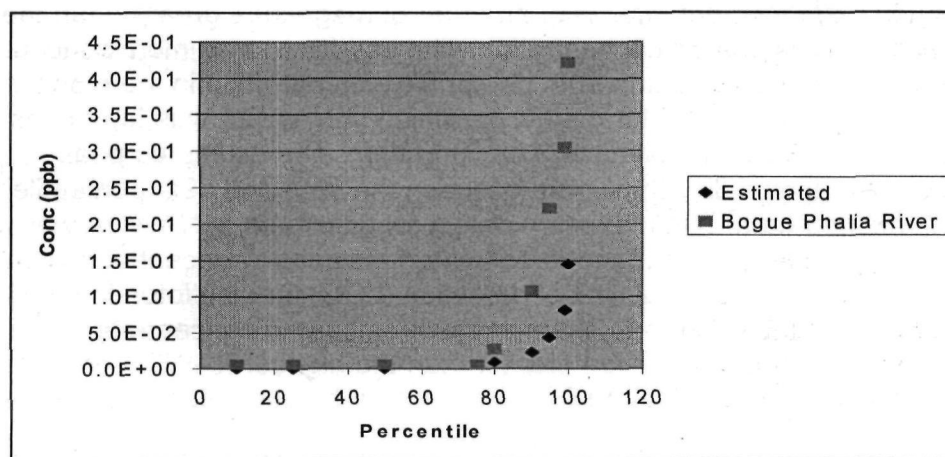


Figure III.E.1-11. Comparison of observed and estimated methyl parathion concentrations in the Mid-South Region.

ii. Summary of NAWQA Monitoring Data in the Region

The **Mississippi Embayment NAWQA** study unit extends from northeast Louisiana along the Mississippi River as it forms the borders of Mississippi, Arkansas, Tennessee and Missouri. The USGS description of the region states that 62% is used for agriculture, up to 90% in areas of intensive row-crop agriculture. About 94% of drinking water supplies in this study unit were derived from ground water in 1995 (USGS Circular 1208).

None of the nine active OPs included as analytes were detected in ground water studies in this study unit. Surface-water sampling resulted in the detection of multiple OPs. Sampling programs included three agricultural streams, one mixed use stream, and one urban stream sampled at least biweekly for two years. In addition, 38 sites from "streams that drained all major crop types grown in the Study Unit" were sampled once each (USGS Circular 1208).

Diazinon and chlorpyrifos were detected in 96% and 100% of urban stream samples, respectively. They were detected in 4% and 6% of agricultural stream samples. Malathion was detected in 56% of urban, 36% of mixed use, and 11% of agricultural samples, with a maximum concentration of 0.616 ug/l (agricultural).

Other OPs were detected in surface water as well. Methyl-parathion was detected in 10% of samples, with a maximum concentration of 0.422 ug/l. Azinphos-methyl was detected in 5 samples, with a maximum detected concentration of 1.0 ug/l. Disulfoton was detected in three samples, with a maximum detection of 0.213 ug/l. Phorate was detected once at 0.2, ethoprop once at 0.206 ug/l, and terbufos twice, with a maximum concentration of 0.173 ug/l.

The U.S. Geological Survey (USGS) Organic Geochemistry Research Group (OGRG) designed a cotton pesticide monitoring study, the results of which are published as the May 1998 USGS Fact Sheet 022-98, "Occurrence of Cotton Pesticides in Surface Water of the Mississippi Embayment." The OGRG collected weekly samples at 8 fixed sites, and collected single samples at another 56 sites in 1996.

Seven different OPs were detected in this study above a detection limit of 0.01 ug/l (<http://ks.water.usgs.gov/Kansas/pubs/fact-sheets/fs.022-98.fig.8.gif>). Dicrotophos was detected in 35% of samples, methyl parathion in 18%, and profenofos and malathion in 12%. Sulprofos, chlorpyrifos and azinphos-methyl were also detected. The 90th percentile concentration detected for all OPs was 0.3 ug/l or less.

The high rate of detection in this study correlates to high use of these OPs on cotton. Methyl parathion, profenofos and dicotophos are applied extensively to cotton. The OGRG reported that although profenofos was used three times as much as dicotophos, dicotophos was much more frequently detected. This is consistent with the shorter persistence of profenofos.

Table III.E.1-18. Magnitude and Frequency of Occurrence of OP Pesticides Analyzed in the NAWQA Study Units in the Mid-South Region.

Land Use	Value	chlorpyrifos	diazinon	disulfoton	ethoprop	malathion	azinphos methyl	methyl parathion	phorate	terbufos
Concentration (ug/L)										
Mississippi Embayment										
All Locations	Maximum	0.251	1.050	0.213	0.206	0.616	1.000	0.422	0.244	0.173
	99th	0.134	0.376	0.021	0.005	0.488	0.521	0.274	0.011	0.017
	95th	0.041	0.125	0.021	0.005	0.147	0.146	0.082	0.011	0.017
	90th	0.019	0.010	0.017	0.003	0.047	0.050	0.022	0.002	0.013
	80th	0.005	0.003	0.017	0.003	0.017	0.001	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.012	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	13.2%	14.3%	0.9%	0.3%	26.2%	1.5%	10.1%	0.3%	0.6%
Agriculture	Maximum	0.200	0.020	0.071	0.005	0.616	0.0654	0.422	0.011	0.017
	99th	0.049	0.017	0.021	0.005	0.311	0.500	0.285	0.011	0.017
	95th	0.010	0.005	0.017	0.003	0.062	0.106	0.108	0.002	0.013
	90th	0.004	0.002	0.017	0.003	0.020	0.020	0.044	0.002	0.013
	80th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	5.2%	4.2%	0.9%	0.0%	15.6%	0.5%	10.4%	0.0%	0.0%
Urban	Maximum	0.251	1.050	0.021	0.005	0.560	0.0427	0.061	0.011	0.017
	99th	0.223	0.897	0.021	0.005	0.511	0.0427	0.058	0.011	0.016
	95th	0.133	0.451	0.020	0.004	0.334	0.048	0.035	0.008	0.013
	90th	0.089	0.380	0.017	0.003	0.173	0.018	0.006	0.002	0.013
	80th	0.077	0.342	0.017	0.003	0.072	0.001	0.006	0.002	0.013
	75th	0.069	0.319	0.017	0.003	0.050	0.001	0.006	0.002	0.013
	50th	0.036	0.154	0.017	0.003	0.012	0.001	0.006	0.002	0.013
	Frequency	92.9%	96.4%	0.0%	0.0%	57.1%	3.7%	7.1%	0.0%	3.6%
Mixed	Maximum	0.186	0.242	0.213	0.206	0.560	0.900	0.312	0.244	0.173
	99th	0.052	0.042	0.036	0.021	0.526	0.630	0.126	0.030	0.029
	95th	0.011	0.010	0.021	0.005	0.217	0.300	0.055	0.011	0.017
	90th	0.005	0.006	0.020	0.005	0.095	0.120	0.020	0.009	0.017
	80th	0.004	0.004	0.017	0.003	0.027	0.050	0.006	0.002	0.013
	75th	0.004	0.002	0.017	0.003	0.024	0.029	0.006	0.002	0.013
	50th	0.004	0.002	0.017	0.003	0.005	0.001	0.006	0.002	0.013
	Frequency	7.5%	12.9%	1.1%	1.1%	41.9%	3.3%	10.8%	1.1%	1.1%

III. Appendices

E. Water Appendix

2. Summary of State Monitoring Programs

The EPA Office of Pesticide Programs (OPP) contacted State Lead Pesticide Agencies in October and November, 2001 to inquire whether OP insecticides were included in ground-water or surface-water monitoring programs over the last decade. When monitoring programs were performed by agencies other than the Lead Pesticide Agency, these were contacted, as well. If OP monitoring data were available for a particular state, OPP inquired whether the data were available over the Internet. Many State Agencies offered to provide data if information has not yet been made available online.

The majority of State monitoring programs included few OPs in their analysis, if any. The majority of States have focused monitoring efforts on ground-water monitoring, including monitoring of five herbicides under the Pesticide Management Plan. With few exceptions, such as California's program to evaluate the effect of OP dormant spray applications on surface-water quality, State monitoring programs have not specifically been targeted to the areas and timing of OP application. Because of this, and because OPs are not yet required by the Safe Water Act to be included as analytes in drinking water sampling, data from State monitoring programs are used as important supplemental data for the OP cumulative drinking-water risk assessment.

a. Alabama

Tony Cofer, Pesticide Administrator of the Alabama Department of Agriculture and Industry Groundwater Protection Section, reports that OPs have not been included in joint sampling with the Alabama Department of Environmental Management. If analysis using immunoassay methods indicated detections of pesticides above 1 ppb, a full gas chromatography scan was done. In addition, a full scan was performed every 10 samples.

Dr. Enid Probst of the Alabama Department of Environmental Management does not recall if OPs were ever detected. However, no more than 1% of samples taken in the program had detections of pesticides other than those in the Pesticide Management Plan. This could be due in part to the detection limits used by the State Agricultural Lab earlier in the program. If OPs were detected at any point, it was not because of systematic, targeted monitoring in OP use areas.

b. Alaska

Rose Lombardi of the Department of Environmental Conservation Pesticide Program reported that Alaska does not look for OPs in drinking

water. The pesticide program has done some outreach by offering domestic well testing, mostly for 2,4-D.

c. Arizona

The Agency has not obtained monitoring data from the State of Arizona.

d. Arkansas

Charles Armstrong, Assistant Director of the Arkansas State Plant Board reported that Arkansas has detected a few herbicides in ongoing ground-water monitoring since 1992, but no OPs.

e. California

The California Environmental Protection Agency Department of Pesticide Regulation (CDPR) performed a 10-year study of **rice pesticides in surface water**, which included methyl parathion and malathion. CDPR samples the Colusa Basin Drain, an agricultural discharge channel that collects outflow from rice fields from about 20 to 100 miles north of Sacramento, and west of the Sacramento River. This area is used for many continuous miles of rice monoculture on heavy clay soils.

According to the CDPR, methyl parathion was detected at concentrations of up to 6 ppb in 1989. CDPR was concerned with surface water contamination by a suite of rice pesticides. By the late 1980s, CDPR had instituted a control program to reduce the surface water impacts of rice herbicides. In the early 1990s, the CDPR expanded the program to include rice insecticides.

The program includes both irrigation and application controls to reduce direct input of pesticides to the Colusa Basin Drain, which drains to the Sacramento River. Rice farmers are required to hold water on flooded rice fields for prescribed periods of time before releasing it to the drainage system, periods which depend on the pesticides applied. The holding time for methyl parathion is 24 days, but it is held longer if applied concurrently with another pesticide that must be held longer. A voluntary holding time of 4 days is suggested for malathion. Application controls include requirements such as positive shutoff systems for aircraft nozzles, use of drift control agents, and a 300-foot buffer from water bodies for aerial applications.

CDPR has seen measurable improvements in the samples they have taken each year from early or mid-April to mid-June. For instance, the peak concentration of methyl parathion detected in 1996 was 0.12 ppb. A maximum concentration of 0.107 ppb of methyl parathion was detected in 32 samples taken in 1997. A single detection of <0.1 ug/l of malathion was

detected in 1997. These data reflect successful mitigation, and also a reduction in methyl parathion use in the area over 15 years.

The California Department of Pesticide Regulation and the USGS have ongoing studies investigating OP contamination from winter use as a **dormant spray to tree fruits and tree nuts**. Since the series of CDPR dormant spray studies focus sampling on pesticides used in the area, coinciding with when they were applied, the frequency and concentrations of OP detections have both been relatively high. For instance, in sampling in the winters of 1991-1992 and 1992-1993, diazinon, methidathion and chlorpyrifos were detected in 72, 18 and 10% of 108 samples collected in the San Joaquin River Basin, respectively. Dimethoate was detected in 60% of samples taken in the watershed in the summer of 1992, at concentrations up to 2.4 ug/l. Azinphos-methyl, chlorpyrifos, diazinon and methidathion were also detected in summer sampling.

Sampling in the Sacramento River watershed has also led to detections of OPs from dormant spray use. Diazinon and methidathion, the two most important tree fruit and tree nut dormant spray insecticides in the watershed, were detected at levels toxic to some aquatic invertebrates. Concentrations and frequency of detection of diazinon was greater than that of methidathion. Details of the detection of diazinon in studies performed by the State of California can be found in the diazinon Reregistration Eligibility Document, which is available on the internet at <http://www.epa.gov/pesticides/op/status.htm>.

Frank Spurlock of the CDEP has written a paper on the findings of chlorpyrifos and diazinon in surface water. This paper, which has not yet been published, is a summary of about 30 monitoring studies, including samples from the Sacramento and San Joaquin Rivers and their tributaries, as well as agricultural drains. The monitoring was predominantly from streams affected by agricultural runoff. Urban data is limited, but urban concentrations were much higher.

Agricultural loading was the most significant load of these chemicals in the Sacramento River. Small streams in the Sacramento basin had the highest agricultural detections. Of approximately 3900 individual samples for diazinon a very small percentage exceeded the lifetime Health Advisory of 0.6 ppb in rivers and tributaries. None of the 3700 samples for chlorpyrifos had concentrations that exceeded the lifetime Health Advisory of 20 ppb. Overall, concentrations of chlorpyrifos were lower than those of diazinon. In general, based on analysis which will be available when the paper is published, overall concentrations in the winter application months have declined since a decade ago, corresponding with reductions in use (Frank Spurlock, personal communication).

A **prospective ground-water monitoring study for fenamiphos** use on grapes in California was begun in October, 1997, and preliminary information

and monitoring results have been submitted in interim and progress reports. Interim reports indicate that fenamiphos and its sulfone and sulfoxide degradates were found in soil-pore water and ground water after one application of 6 lb A.I./acre. Fenamiphos and fenamiphos sulfone were detected in one ground-water sample, at concentrations of 0.05 and 0.53 ppb respectively, 216 days after treatment (DAT). Fenamiphos sulfoxide was detected in ground water samples from four of eight well clusters, at concentrations up to 2.13 ppb. These concentrations can be considered as a lower bound measure of the peak concentrations of total fenamiphos residues in ground water resulting from use of fenamiphos on HSG A soils. It is likely that application to similar soils in areas with higher rainfall or at higher applications rates will result in higher groundwater concentrations. A similar study on more vulnerable soils in the Florida Central Ridge resulted in significantly higher ground-water detections.

The California Department of Pesticide Regulation is currently sampling "about 40 **domestic wells for fenamiphos** in high use areas" (Robert Matzner, CDPR, written communication to EPA). Twenty-eight wells sampled in 2001 did not have detections of fenamiphos, fenamiphos sulfoxide, or fenamiphos sulfone. This sampling program is ongoing. These OPs were also not detected in 803 wells sampled in California from 1985 to 1994.

California has a ground-water monitoring database required under their Pesticide Contamination Prevention Act that includes data since 1984. No OPs are among the pesticides California reports as having "verified" detections in more than 20,000 wells sampled since 1984.

f. Colorado

Brad Austin of the Colorado Department of Health reported that diazinon and malathion were detected in ground water one time each in 784 wells since 1992. Chlorpyrifos and dimethoate were also included, but not detected in monitoring.

g. Connecticut

Judith Singer of the Connecticut Department of Environmental Protection Pesticide Management provided data from a USGS report which covers monitoring of the Connecticut, Housatonic and Thames Rivers from 1969 to 1992. This report indicates that diazinon was detected in 3 surface water samples from 0.01 to 0.03 ppb (although a detection limit of 10 ppb was reported). Chlorpyrifos, diazinon, and phorate were detected once each at 0.01 ppb, and a single detection of "total diazinon" occurred at 0.07 ppb.

Connecticut's main focus for ground-water monitoring is the Pesticide Management Plan (PMP).

h. Delaware

Scott Blaier, a hydrologist with the Delaware Department of Agriculture, indicated that chlorpyrifos was detected one year in domestic and monitoring wells. As part of the PMP program, chlorpyrifos was included in 1998. The top of the well screen of 70% of the "domestic and agricultural wells" sampled was between 16 and 35 feet. Top of screen for 80 percent of the monitoring wells was shallower than 15 feet.

Chlorpyrifos was detected in a single well (LOD = 0.22 ppb) at a concentration of 0.75 ppb. This was a domestic well screened between 33 and 38 feet. Details of the monitoring program are available in "The Occurrence and Distribution of Several Agricultural Pesticides in Delaware's Shallow Ground Water", 2000: <http://www.udel.edu/dgs/pub/RI61.pdf>

i. Florida

Keith Parmer of the Florida Department of Agriculture and Consumer Services provided results of three ground-water monitoring programs (plus data from an additional background well network) which included OPs as analytes. Seventeen OPs and transformation products are included as analytes among these three studies:

azinphos-methyl, chlorpyrifos, diazinon, dichlorvos, disulfoton, ethion, ethoprop, fenamiphos, fenamiphos sulfone, fenamiphos sulfoxide, malathion, methamidophos, methyl parathion, methyl paraoxon, naled, phorate and terbufos.

The three studies include both monitoring and drinking water-supply wells:

The Florida Department of Environmental Protection and the Florida Department of Health in which "up to 50 private drinking water wells were selected from each of Florida's 67 counties, to be sampled for a fairly comprehensive list of ground water contaminants. As of 1998, wells from approximately 26 counties had been sampled. The extent to which the selected wells represent either the private drinking water resource or the ground water resource is unknown" (Keith Parmer, personal communication).

This data set includes 7016 "determinations" for OP insecticides. "Determinations" are the total number of analyses made for OPs, including duplicates and split samples. No OPs were detected in these samples "without qualifiers."

The second dataset included results from the "Very Intense Study Area Network." There have been 22 VISA studies to date, "with 7-45 well/spring stations located in each VISA. VISA sample stations were deliberately located to fall within particular land use/vulnerability domains; the water

quality in these areas may very likely be impacted by human activities" (Keith Parmer, personal communication). No OP was detected in 12,136 determinations for OPs in this data set.

A follow-up monitoring program to that performed by the FDEP and the FDEH include private and public drinking water supply wells. This dataset includes 7411 determinations for OPs. Fenamiphos sulfoxide was detected in five samples in 2 wells from this study in 1992 and 1993. The maximum concentration detected in both wells was 1 ug/l.

Mr. Parmer reported that a "Lake Wells Ridge monitoring network" included shallow ground-water samples analyzed for OPs. He related that other compounds have been detected in this study, but not OPs.

j. Georgia

Doug Jones of the Department of Agriculture indicated that GDA has a Pesticide Monitoring Network in conjunction with the Georgia Geological Survey. This ground-water monitoring program includes annual sampling of a wide number of pesticides, including OPs included in EPA method 507. Before 1999, NAWQA monitoring wells were included in the program. Recently, GDA has limited sampling to domestic wells, and excluded monitoring wells. Sampling has been mostly in southern, agricultural portion of state, which includes recharge areas for the Floridan aquifer. Wells in the program are located where the water table is shallower than 100 feet.

Reports from the last three years indicate that no OPs were detected in samples from this network. Previous studies indicate that no pesticides were detected above MCLs; OP insecticides have not yet been assigned MCLs.

k. Hawaii

Robert Boesch of the Department of Agriculture Pesticides Branch described a drinking-water study conducted in March, 2001. In preparation for the OP risk assessment, Hawaii sampled 36 drinking-water wells in areas where OPs are used on pineapples, or for urban use. These water supply wells, which have shown contamination for other organic chemicals, did not have detections (LOD 0.5 ppb) of the following OPs:

acephate, azinphos methyl, chlorpyrifos, DDVP, demeton, diazinon, dimethoate, disulfoton, ethoprop, fenamiphos, malathion, methidation, methyl parathion, mevinphos, monocrotophos, naled and parathion.

l. Idaho

Gary Bahr of the Idaho Dept of Agriculture Division of Agricultural Technology indicated that Idaho tests for OPs on a routine basis. There have been occasional, rare detections of diazinon and methidathion.

m. Illinois

Dave McMillan of the Illinois Environmental Protection Agency Bureau of Water's Ground Water Section indicated that Illinois has focused ground-water monitoring on herbicides since 1993, due to reduced funding. The Illinois Source Water Protection Program, which will lead to assessment of the State's community and non-community water supplies, does not include OPs. Ambient lake monitoring done by the State also does not include OPs.

n. Indiana

Ryan McDuffee, an Environmental Scientist with of the Indiana Department of Environmental Management Office of Water Quality sent data sets of pesticides detected in surface water during their 5 year "Surface Water Quality Assessment Program." The program has tested for 226 pesticides and semi-volatile compounds using EPA methods 525.5 and 547. The first of these methods includes many OPs. Three years of data are available, and Mr. McDuffee provided spreadsheets of detections in these three years. Only one OP, stirofos, was detected in the three years of sampling.

- ☐ 1997- Stirofos, a cattle OP detected at 0.1ppb in 898 records of stream-water detections.
- ☐ 1998- No OPs detected in 1416 records of stream-water detections
- ☐ 1999- No OPs detected in 563 records of stream-water detections

Al Lao of the Indiana Department of Environmental Management indicated that OPs are not included in surface-water or ground-water drinking water analyses, as they are not required to be by the Safe Drinking Water Act.

o. Iowa

Mary Skopec, Acting Section Supervisor of the Iowa Department of Natural Resources' Water Monitoring Section, reports that "Iowa's ambient water monitoring program was expanded in 1999 in response to increased appropriations from the State. Prior to 1999, very little state money was spent on money and nearly all ambient monitoring was paid for by EPA. Therefore our monitoring program was constructed to provide basic information (water chemistry and nutrients). Since 1999, we have been working to expand the number of sites and the types of analyses conducted as part of our monitoring program. Due to the severe restrictions in funding, OPs were not very often included in the monitoring programs."

Chlorpyrifos, ethoprop, fonofos, phorate, terbufos, dimethoate, diazinon, malathion, and parathion were included in Iowa's Statewide Rural Well-Water Study. This study included 686 private wells sampled once during 1988-89, with 10% of the private wells repeat-sampled during 1990 and 1991. None of the OPs were detected in this study. After the conclusion of the SWRL study, private wells continued to be monitored as part of Iowa's Grants to Counties program, but not for pesticides.

Iowa has a cooperative program with the USGS to sample 90 municipal wells on a four-year cycle. Iowa samples 45 wells in surficial materials (alluvial and Pleistocene) each year; bedrock wells are cycled in based on vulnerability to contamination. Twenty-two "vulnerable" wells are sampled every two years, and 23 "protected" wells are sampled every 4 years. OPs are not included in this monitoring.

i. Future ground-water monitoring

Beginning this winter, domestic well monitoring will examine the occurrence of many different contaminants (including OPs) in communities without public water supplies. Dedicated groundwater wells are being drilled to assess the quality of water in many different aquifers around the state. Sampling has not begun, but a wide array of analyses will be run on these wells (at least initially) to characterize water quality. This program may include OPs, depending on budgets.

ii. Surface Water Monitoring

Iowa's Ambient Surface Water Monitoring program has included about 80 sites (including 23 up/downstream of 10 major cities) in two years of sampling. Sampling during the first year included two analyses for OPs (Fall of 1999 and Spring of 2000), and samples in the second year were collected and analyzed for OP insecticides during April, May, June, and July, 2001. Only one detection of parathion and two detections of chlorpyrifos have occurred since 1999. Concentrations detected were low, in the 0.05 ppb range. In 2002, Iowa will sample and analyze for OP insecticides during April, May, June, and July.

p. Kansas

Theresa Hodges of the Kansas Department of Health and Environment reports that of the OPs, only diazinon has been detected in their routine ambient surface water quality sampling network. While diazinon is not on the list of pesticides routinely included, it was added because it had been detected. Since 1995, 44 detections were found at 16 urban or golf course sites. The range of detections was from 0.19 to 1.5 micrograms/liter.

Dale Lambley, Special Environmental Assistant to the Secretary of the Kansas Department of Agriculture sent information on their ground-water monitoring of chemigation wells. The objective of the study "is to assess and monitor groundwater quality by obtaining water samples at selected chemigation sites located at agricultural irrigation wells." In sampling from 1987 to 2000, chlorpyrifos was detected three times at concentrations of 1.9, 3.5 and 4.2 ppb (LOD = 0.5 µg/l). Dimethoate, disulfoton and methyl parathion were included in sampling, but were not detected above detection levels of 2.0, 0.5 and 1.0 µg/l, respectively.

The 100 samples taken annually are apportioned among five Groundwater Management Districts based on the number of registered chemigation sites in each. Highest priority is given to finding active chemigation sites. Ranking of wells has also been based on proximity to public water supplies (within 3 miles), depth to water, soil type, and whether chemigation misuse is suspected.

q. Kentucky

Peter Goodman of the Kentucky Division of Water reports that the following OPs are included in their ground-water monitoring program: acephate, chlorpyrifos, diazinon, disulfoton, ethoprop, malathion, methyl parathion and terbufos. Each was included in more than 1300 analyses from over 300 wells, but only diazinon, chlorpyrifos and malathion were detected.

Chemical	# Wells	# Samples	# Detections	Max. Conc.
Diazinon	362	1809	10	0.17 ppb
Chlorpyrifos	398	2057	7	7.1 ppb
Malathion	364	1821	2	0.32 ppb

r. Louisiana

Karen Irion indicated that it is very unlikely that Louisiana would have analyzed drinking water for OPs, since they have not been required up to now by the Safe Drinking Water Act.

s. Maine

Julie Chizmas, Senior Water Quality Specialist of the Maine Department of Agriculture Board of Pesticides Control wrote that Maine samples drinking water wells no more than 1/4-mile down-gradient of an active pesticide use site. Analytes are chosen based on local sales data. Sampling took place in 1994 and then in 1999, and included the following OPs:

azinphos methyl, chlorpyrifos, diazinon, ethoprop and phosmet.

No OPs were detected in 1999. One detection of diazinon in 1994 (7.4 ppb) was determined to be the result of a homeowner putting diazinon around her well head to get rid of ants. Ethoprop was detected in one well at 0.075 ppb. No followup to that detection was conducted.

Surface-water monitoring in Maine has included the following OPs:

azinphos methyl, chlorpyrifos, diazinon, ethoprop, malathion and phosmet.

Most surface-water monitoring in Maine is in response to the endangered species designation for Atlantic salmon. "Blueberries are the most intensively grown commodity in the salmon watershed." Only phosmet has been detected to date in surface water, with a maximum detection of 0.52 ppb (3 detections). In this study, surface water samples were collected less than 2 hours after a phosmet application. Sampling continues in that watershed, except for ethoprop.

t. Maryland

Rob Hofstedter of the Maryland Department of Agriculture reports that their agency has a current ground-water study that includes diazinon. Results of this study are not yet available. He referred me to the Maryland Geological Survey for information on previous surface-water studies which included malathion.

David Bolton of the Maryland Geological Survey provided summary tables from the MGS Report of Investigations number 66, "Ground-Water Quality in the Piedmont Region of Baltimore County, Maryland." Analysis in this rural region included 12 OPs, 10 of which are still registered. Seven of the 10 current OPs were not detected in ground water. Results of the monitoring are as follows, which concentrations in µg/l.

Pesticide	# samples	MRL	>=MRL	<MRL	Maximum Conc.
Azinphos-methyl	112	0.001	0	0	
Chlorpyrifos	112	0.004	0	0	
Diazinon	112	0.002	1	0	0.003
Dimethoate	1	0.004	0	0	
Disulfoton	112	0.017	0	0	
Ethoprop	112	0.003	1	1	0.004
Fonofos	112	0.003	0	0	
Malathion	112	0.005	0	0	
Methyl parathion	112	0.006	0	0	
Parathion	112	0.004	1	0	0.022
Phorate	112	0.002	1	0	0.010

Terbufos	112	0.013	0	0
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MRL = Minimum Reporting Limit

Surface-water sampling at 8 sites at the Pocomoke River in 1998 did not result in detections of chlorpyrifos, dimethoate, malathion or terbufos above levels of detection. One sample included a "trace" level of terbufos, reported as between 0.07 and 0.1 ppb.

u. Massachusetts

Kenneth Pelotiere of the Massachusetts Department of Environmental Protection Source Water Assessment Program indicated that over the last 10 years, testing of surface water and ground water has been for pesticides required under the Safe Drinking Water Act. Therefore, OPs have not been included as analytes.

v. Michigan

Dennis Bush from the Surface Water Quality Division has sent information on a study of tributaries of the Saginaw River, which included OPs as analytes. The Agency has not yet reviewed this data.

Mark Breithart of the MDEQ Drinking Water Division examined their database, and found that analysis was done for the following OPs in Michigan drinking water:

azinphos methyl, chlorpyrifos, diazinon, dimethoate, disulfoton, fenamiphos, malathion, methyl parathion

None of these were detected in 49 analyses of public water supplies. Of the 421 analyses from private water supplies, only dimethoate was detected. This single detection of 2 micrograms/liter occurred at an aerial spray service, and therefore it is not clear if it was the result of a point source.

w. Minnesota

Daniel Helwig reported that the Minnesota Pollution Control Agency does not have ground-water monitoring data for insecticides.

Mark Zabel of the Minnesota Department of Agriculture reported that OPs are not included on the list of pesticides included in surface-water and ground-water monitoring. Although pesticides are added if they are identified in anomalous gas-chromatography peaks, he cannot recall any OPs being so identified.

x. Mississippi

Rusty Crowe reported that the Mississippi Department of Agriculture and Commerce Bureau of Plant Industry has not conducted ground-water monitoring since performing an atrazine study in the mid-1990s.

Shedd Landreth of the Mississippi Department of Environmental Quality reports that about 125 wells a year are included in the Mississippi Agricultural Chemical Ground-Water Monitoring Program. This program, which is funded by user fees, concentrates on existing shallower wells, including drinking wells and irrigation wells, and is patterned after the EPA's National Pesticide Survey.

A number of OPs are included in their analytical method. However, if other peaks are found in GC analysis, they are identified. Since 1989 through present, 910 wells in the state have been sampled, concentrating in areas of pesticide usage. Out of 910, chlorpyrifos was detected in 3 wells, with a concentration range of 0.002 to 0.22 ug/l. Diazinon was detected in one well early in the study at a concentration reported as "trace".

Profenofos was detected in three samples collected from center-pivot irrigation system. Mr. Landreth collected these samples himself, and noted at the time that he believed the samples had suffered from cross contamination from the irrigation equipment itself, resulting from application the day before. Resampling the next day resulted in non-detections.

Malathion was also detected in one well. Mr. Landreth suspects this may also have been external contamination, because malathion was being aerially applied in area.

y. Missouri

Paul Andre, Program Coordinator of the Department of Agriculture Plant Industries Division indicated that the Department of Natural Resources undertakes water monitoring. Terry Timmons of the Department of Natural Resources explained that they sample surface water and ground water used as drinking water, and analyze for pesticides using several EPA methods. However, although method 507 can include OPs, Missouri does not include them among the analytes.

John Ford from the Department of Natural Resources sent 1997 to 1999 stream-water monitoring data from their Water Pollution Control Program for diazinon, chlorpyrifos and malathion. Results from the fixed-station database are as follows:

diazinon: 124 detections in 330 samples, range 0.001 to 0.976 ppb;
chlorpyrifos: 50 detections in 328 samples, range 0.001 to 0.691 ppb;
malathion: 36 detections in 223 samples, range 0.004 to 0.325 ppb.

z. Montana

Donna Rise of the Montana Department of Agriculture (MDA) Agricultural Sciences Division Technical Services Bureau reports that the MDA samples ground water for pesticides generally, although the Department of Environmental Quality undertakes monitoring on a "project or issue basis". The State has specific criteria under which to put pesticides in a "Groundwater Management Plan". The only current management plan is for imazamethabenz methyl.

Montana currently has a network of 14 shallow wells throughout the state, which are <50 feet deep, "most between 13 and 35 feet." These wells are sampled twice a year, in the spring before application, and in the fall post-harvest. Analytes are chosen based on use. In addition, a "Domestic Rural Monitoring Program" took place from 1992 to 1995, and included two domestic wells in each county.

There was a single detection of malathion in a 35-foot well drilled into "a cobbly or gravelly loam." The detection was at a concentration of 4.8 ppb in May 1999. A sample from the same well in June was estimated at 0.017 ppb (LOQ = 0.4), and there was no detection in July, October or December. Although this was a very vulnerable well, there also had been a dirt-floor storage shed 10 feet unpradient of the well three years before. MDA is not certain that the single detection reflected normal agricultural use.

aa. Nebraska

Craig Romary of the Nebraska Department of Agriculture Bureau of Plant Industry indicated that Nebraska maintains the "Quality-Assessed Agricultural Contminant Database for Nebraska Ground Water," which was created from ground water quality data submitted by many organizations." The following OPs are included in the database:

- Chlorpyrifos- No detections in 3936 aalyses.
- Diazinon- No detections in 190 analyses.
- Disulfoton- No detections in 185 analyses.
- Ethion- No detection in 1 analysis.
- Malathion- No detections in 31 analyses.
- Methyl parathion- No detections in 3679 analyses.
- Phorate- No detections in 182 analyses.
- Terbufos- No detections in 4729 analyses.

The levels of detection are generally below 1 ppb.

Mr. John Lund, supervisor in the Surface Water Unit of the Nebraska Department of Environmental Quality, indicated that OPs have not been included in the State's surface-water monitoring.

bb. Nevada

Scott Cichowlaz reported that malathion, diazinon and guthion were found at low levels in some ground-water monitoring studies. Perhaps 200 shallow wells that are 10 to about 90 feet deep are included in this study. These include monitoring wells installed by the State, NAWQA wells, and water authority wells. Each year a subset of 50 to 70 wells is sampled. Nevada has monitored all agricultural uses in the State, and looked only at active products, used in the areas where they are looking.

In most cases sampling was from drinking water wells, some of which are perforated pipe from surface down. The State hasn't found pesticides in the drinking water wells.

cc. New Hampshire

The New Hampshire Department of Environmental Services does not include the OPs in drinking water analysis. The state does not include OPs in systematic ground-water monitoring, which is focused on the Pesticide Management Plan program. Pat Bickford of the NHDES indicates that some monitoring of OPs has occurred, but only when the Department of Agriculture investigating misuse for enforcement, or rarely at the request of a homeowner.

dd. New Jersey

Dr. Roy Meyer of the New Jersey Department of Environmental Protection (NJDEP) Pesticide Monitoring and Evaluation group indicated that NJDEP has not detected OPs in its ground-water monitoring program. The wells in this program are mostly concentrated in the agricultural areas of southern New Jersey. The wells are shallow (<30 feet), and are intended to give a sense of pesticide migration through the vadose zone.

Another program is in place for the Pesticide Management Plans.

ee. New Mexico

The surface water program in New Mexico monitors stream samples over a 5 year cycle. The program is done in order to meet requirements of the Total Maximum Daily Load program. The State attempts to look at more extreme conditions, such as storm-water or low-flow conditions. The State runs the EPA method 8270, which includes many OPs.

Before 1998, all of their data were entered into STORET (21-NEX is their STORET code). The State is attempting to move to an ACCESS- based database, but this more recent data is not entered yet.

ff. New York

Jeff Myers of the New York Department of Environmental Conservation Bureau of Technical Support says that the emphasis in New York is bottom sediments and fish tissue, with little sampling in the water column. This sampling has concentrated more on organochlorines, although some less persistent pesticides have recently been included.

gg. North Carolina

Dr. Henry Wade, Environmental Programs Manager of the North Carolina Department of Agriculture and Consumer Services described the "Interagency Study of the Impact of Pesticide Use on Ground Water in North Carolina," which took place between 1991 and 1995. Sampling of mostly shallow monitoring wells was performed based on information by farmers on which pesticides they used within 300 feet of the wells. By the end of the study, more than 240 pesticides were included as analytes.

Sixteen OPs were included in the analysis, but none were detected. The number of wells sampled for each OP is shown below:

acephate (23 wells), azinphos-methyl (7), chlorpyrifos (25), diazinon (8), dimethoate (5), disulfoton (12), ethoprop (6), fenamiphos (4), fonofos (1), malathion (9), mevinphos (1), parathion (5), phorate (3), phosmet (2), terbufos (13) and trichlorfon (2).

Other pesticides were detected in these wells, especially herbicides. The main focus of the study was herbicides which the EPA had identified as "potential leachers."

A separate study of domestic wells resulted in a single detection of diazinon at 0.55 ppb. It is not clear if this was the result of domestic use.

hh. North Dakota

Bill Schuh of the North Dakota State Water Commission described the ground-water monitoring program run by the ND Department of Health. About 150 to 200 wells are sampled each year, and OPs are included among the analytes. More vulnerable aquifers are sampled on a one square-mile grid, with a bias toward shallow wells. This sampling occurs once every five years, and annual reports are available since 1992.

Norene Bartelson of the NDDoH provided further information. In its "Ambient Groundwater Monitoring Program," the NDDoH has collected "approximately 2,700 samples from 1465 wells." This program includes five OPs: chlorpyrifos, diazinon, ethyl parathion, methyl parathion and malathion. There have been OP detections in six wells over that time:

Well #	Date Sampled	Analyte	Concentration	Sample Type
15105504AAA	6/23/93	Ethyl Parathion	1.833 µg/l	Regular
	9/29/93	None		Regular
15305532AAA	6/23/93	Ethyl Parathion	0.274 "	Regular
	6/23/93	Ethyl Parathion	0.322 "	Duplicate
	5/11/94	None		Regular
13705228CAA	5/04/99	Malathion	0.379"	Regular
	5/04/99	Malathion	0.460 "	Duplicate
	9/21/99	None		Regular
14708011CAA	7/11/00	Malathion	0.171"	Regular
	1/30/01	None		Regular
15410113AAB	7/18/01	None		Regular
	9/13/01	Malathion	0.340 "	Regular
16305620BDC	6/26/01	None		Regular
	9/11/01	Diazinon	0.100 "	Regular

ii. Ohio

Only chemicals with MCLs are included in Ohio water monitoring programs, and therefore no OP insecticides (Todd Kelleher and Julie Letterhos, Ohio Environmental Protection Agency, personal communication). The "Ohio EPA Pesticide Special Study," a 4-year study which examined pesticides which might be found in finished drinking water, also did not include OPs.

OPs are not part of routine sampling, although Ohio does some watershed-specific monitoring (Gail Hess, OEPA, personal communication). Data collected through 1998 could be extracted from STORET, but anything since then isn't yet electronically available. Several OPs may have been included. The Agency will evaluate the data in the STORET database.

The Great Lakes represent a significant drinking water supply, but water monitoring of the lakes has not concentrated on OP contamination. According to the State of Ohio's State of the Lake Report, for instance, 31 water-treatment plants on the north shore of Ohio draw water from Lake Erie <http://www.epa.state.oh.us/oleo/leqi/14.pdf>. These systems have not analyzed for OPs to this point, as such analysis was not required by the Safe Drinking Water Act.

These systems are likely to look for triazines once a month in the summer, and quarterly otherwise. Ohio EPA undertook a "pesticide special study"

between 1995 and 1999, but also looked only for herbicides (<http://www.epa.state.oh.us/ddagw/pestspst.html>). Cities like Cleveland and Toledo get their water from intakes a couple of miles into Lake Erie. Therefore, they rarely detect pesticides other than small levels of atrazine at times. Smaller communities might have their intakes somewhat closer to shore (Todd Kelleher, Ohio EPA Dept. of Drinking and Ground Waters, personal communication).

jj. Oklahoma

Don Molnar of the Oklahoma Department of Agriculture Plant Industry and Consumer Services Division indicated that the Pesticide Management Plan is the major monitoring effort currently underway in Oklahoma. While that program does not include the OPs, Oklahoma is performing a general "OP/OC" screen for a study monitoring irrigation tailwater from containerized nurseries, and in wells for their Organic Certification program. The data is not in an electronic format that would permit quick extraction of OP analyses. The specialized nature of these monitoring programs would limit the usefulness of the data for the cumulative risk assessment, in any case.

kk. Oregon

The Agency has not obtained monitoring data from the State of Oregon.

II. Pennsylvania

John Pari of the Pennsylvania Department of Agriculture Bureau of Plant Industry indicated that Pennsylvania has ground-water monitoring programs that are tailored to particular crops uses. This includes a program focusing on corn that has run from 1995 to the present. The wells are described as "water supply" wells, whether as sources for drinking water for humans or livestock.

Chlorpyrifos is the only OP included in this analysis. There have been about 450 analyses to date, and chlorpyrifos was detected in "4 or 5" samples. The maximum concentration detected was 0.29 ppb. Another study is just beginning in orchard areas, and may include other OPs.

mm. Rhode Island

Eugene Pepper of the Rhode Island Department of Environmental Management Division of Agriculture and Resource Marketing reports that in addition to required Safe Drinking Water Act analyses, the Department of Health uses Method 525 to analyze ground water and surface water for chlorpyrifos, diazinon, and by special request, malathion. However, these insecticides have not been detected. Mr. Pepper pointed out that both raw and finished water are tested, but the lab does not include the transformation products in the analysis.

A nearly completed ground-water study for turf chemicals includes chlorpyrifos, but chlorpyrifos has not been detected in this study, either.

nn. South Carolina

Jerry Moore of Clemson University said that South Carolina has not detected OPs in ground water. South Carolina monitors about 150 rural wells (domestic supply, irrigation, shop wells) per year, and runs a broad GC screen. The analysis focuses on 22 pesticides, none of which are OPs. Therefore, the detection limit may be a little higher for pesticides other than the main 22. This program has been ongoing since 1990.

Peter Stone of the Department of Health and Environmental Control reports that South Carolina does not routinely analyze drinking water for anything but those required by the Safe Drinking Water Act. Kathy Stecker of the SCDHEC provided the internet address for the list of pesticides included in the State's ambient surface-water monitoring program (<http://www.scdhec.net/eqc/water/pubs/appd.pdf>). OPs are not included in that list.

oo. South Dakota

Brad Berven of the South Dakota Department of Agriculture Pesticide Program reports that the South Dakota "Statewide Ground Water Quality Network" was sampled between 1989 and 1997. This statewide program was meant to monitor "shallow, sensitive aquifers" in the state for non-point agricultural contamination. Monitoring wells were sampled for a number of chemicals, including pesticides. The wells were generally sampled once per year, although wells with pesticide detections were subsequently sampled four times per year. One aquifer (Big Sioux) was sampled multiple times per year before 1994.

This monitoring program included six OPs: chlorpyrifos, ethoprop, fonofos, parathion, phorate and terbufos. Fonofos and parathion are currently in the process of voluntary cancellation. Chlorpyrifos was not detected in 231 analyses. Ethoprop was not detected in 160 analyses. Phorate was not detected in 230 analyses. Terbufos was not detected in 246 analyses.

pp. Tennessee

Ken Nafe of the Tennessee Department of Agriculture reports that, "We have found some chlorpyrifos in ground water in several wells. The primary source is from termite treatments that followed the supply line into the well and then went down the well casing. We have worked with Dow to clean up all wells successfully."

Mr. Nafe also provided a surface-water monitoring database, which included chlorpyrifos as the only OP in sampling from 1996 to 2001. Chlorpyrifos was not detected in ambient samples, nor in raw or finished drinking water samples.

qq. Texas

The USGS conducted a study of cotton pesticides in playa lakes in the High Plains of west Texas. Dicrotophos was detected in one sample of 32. The study authors indicate that the lack of OP detections could be due to the general short half-lives of these insecticides, but could also be due to sampling that may have occurred before the application of the OPs that season.

rr. Utah

Mark Quilter of the Utah Department of Agriculture and Food directed the Agency to a web page describing their private well monitoring network:

<http://ag.utah.gov/mktcons/groundwater.htm>

Mr. Quilter reported that Utah has not detected any insecticides in five years of sampling, and that a single detection of 2,4-D in a sump well is the only detection in the program to date.

Arne Hulquist of the Utah Department of Environmental Quality reported that their data through 2001 is on STORET, but that they have had few positive pesticide detections.

ss. Vermont

Cary Giguere of the Vermont Department of Agriculture, Food and Markets reports that OPs are not regularly included in their monitoring, but that the State has an OP screen. This is used for enforcement cases, generally. OPs are not included in drinking-water monitoring.

Surface-water monitoring is not only for corn herbicides, but also railroad program, golf course permitting (includes some OPs). Act 250 requires a detailed pesticide management plan to protect surface and ground water. They have a list of pre-screened pesticides, and the state monitors certain courses. The courses must monitor drinking water. State monitors surface water, in order to be sure that permitting is effective in protecting water resources.

In 1999, VDAFM analyzed turf (including lawns and golf courses) pesticides in streams adjacent to a residential complex immediately following a commercial landscape application. Diazinon, chlorpyrifos and malathion

were included in the analysis. Of these, only diazinon was detected (2 samples), at concentrations of 0.08 and 0.22 ppb.

tt. Virginia

Marvin Lawson of the Virginia Department of Agriculture and Consumer Services indicated that Virginia undertook a ground-water monitoring study from the mid- to late-1990s. Daniel Schweitzer of VDACS reported that this study did not include OPs. He is unaware of any Virginia ground-water or surface-water monitoring program that included the OPs as analytes.

uu. Washington

The Agency has not obtained monitoring data from the State of Washington.

vv. West Virginia

Doug Hudson of the West Virginia Department of Agriculture says that West Virginia DoA does intermittent ground water sampling, including an OP screen. He could recall only a single detection of diazinon, which they could not confirm. Other OP detections in ground water were in response to improper termiticide use.

Chad Board of the West Virginia Department of Environmental Protection sent a spreadsheet with analytical results which included the following OPs: chlorpyrifos, diazinon, disulfoton, ethoprop, malathion, phorate, and terbufos. Each were sampled in 12 wells, but not detected. The detection limits ranged from 0.005 to 0.027 ppb.

ww. Wisconsin

Bill Phelps, of the Wisconsin Department of Natural Resources Bureau of Drinking & Groundwater provided a summary of monitoring Wisconsin has done in public and private water supply wells and information on monitoring from their GEMS database performed at regulated/investigated sites.

Analyte	# Water Supply Wells	# Detects in Water Supply Wells	#GEMS wells	# GEMS wells with detections	Maximum concentration detected (ug/l)
chlorpyrifos	1	0	0		
diazinon	12	0	20	9	420
DDVP			20	0	
dimethoate	8	0	127	0	
disulfoton	0		190	9	240
malathion	1	0	20	5	19
methyl parathion	1	0	166	0	
phorate	54	0	199	21	37

xx. Wyoming

Jim Bigelow, manager of the Wyoming Department of Agriculture Technical Services Department, described the generic Pesticide Management Plan ground-water program, which includes a network of 178 wells. A total of 54 active ingredients are included as analytes, including eight active OPs:

azinphos-methyl, chlorpyrifos, diazinon, disulfoton, malathion, methyl parathion, phorate and terbufos.

Mr. Bigelow indicated that there have been detections of pesticides in 117 of 178 wells. The Agency will investigate further details of this program.

III. Appendices

E. Water Appendix

3. Analysis of the USGS-EPA Pilot Reservoir Monitoring Program

a. Introduction

A pilot reservoir monitoring project initiated by the USEPA's Office of Pesticide Programs (EFED/OPP) and Office of Ground Water and Drinking Water (OGWDW), and USGS National Water Quality Assessment (USGS/NAWQA) assessed pesticide concentrations in raw and finished drinking water (Blomquist et al. 2001). Reservoirs were sampled because they are important sources of drinking water and because they store runoff water and pesticide loadings within their watersheds. Twelve water-supply reservoirs (Figure III.E.3-1) and Community Water Systems (CWSs) were selected based on general vulnerability for pesticide contamination. Selection criteria included small watersheds with high pesticide use and high runoff potential, representation across pesticide use areas, integration with ongoing monitoring efforts, and feasibility of monitoring.

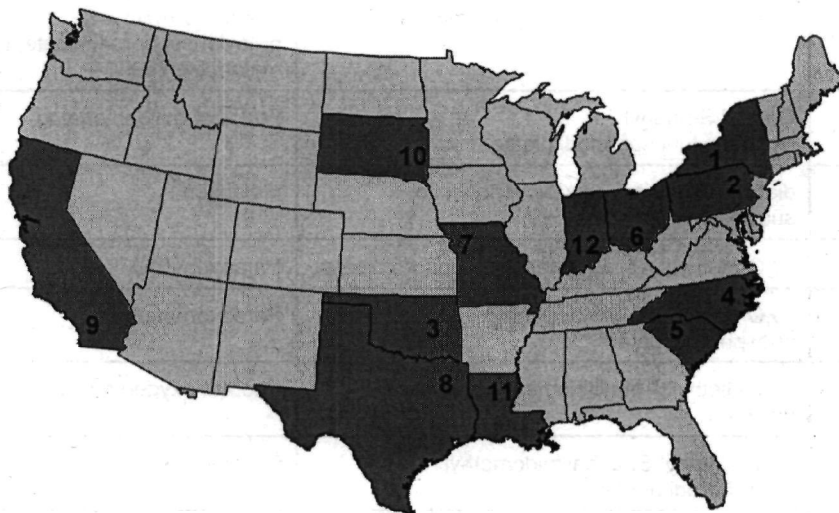


Figure III.E.3-1: Location of Reservoirs in Pilot Monitoring Program

Samples from raw and treated (finished) drinking water and the reservoir outflow provide an integrated water concentration for the reservoir watershed. For each site visit, three samples were collected: 1) raw water from the intake spigot of the public water system, 2) finished water from the compliance tap at the entry point to the distribution center, and 3) ambient reservoir water sample at the reservoir outlet. Samples were taken bi-weekly during the period of intensive pesticide use, such as the post-pesticide application season, and quarterly beyond the four-month post-application period. Two

sites were sampled at weekly intervals for six months after the application season to improve the estimate of peak concentrations for short-lived compounds. Raw and finished drinking water samples were taken at most sampling times and analyzed using the USGS analytical schedules 2001, 9060, and 9002. Finished water samples were not quenched to eliminate chemical oxidation from residual chlorine. Out of 186 pesticides and degradation products analyzed, 46 were organophosphorus (OP) pesticides and their degradation products (Table III.E.3.1).

Table III.E.3.1. Organophosphorus pesticides and degradation products included in the reservoir study, USGS Analytical Schedules (2001 and 9002).

PESTICIDE	IUPAC NAME	DEGRADATES
Azinphos-methyl	S-(3,4-dihydro-4-oxobenzo[d]-[1,2,3]-triazin-3-ylmethyl) O,O-dimethyl phosphorodithioate	Azinphos-methyl-oxon
Chlorpyrifos	O,O-diethyl-O-3,5,6-trichloro-2-pyridyl phosphorothioate	Chlorpyrifos, oxygen analog
Diazinon	O,O-diethyl-O-2-isopropyl-6-methylpyrimidin-4-yl phosphorothioate	
Disulfoton	O,O-diethyl S-2-ethylthioethyl phosphorodithioate	Disulfoton sulfone, Disulfoton sulfoxide
Ethoprop	O-ethyl S,S-dipropyl phosphorodithioate	O-ethyl-O-methyl-S-propylphosphorodithioate, Ethoprop metabolite 76960
Fonofos	O-ethyl S-phenyl (RS)-ethylphosphonodithioate	Fonofos, oxygen analog
Malathion	diethyl (dimethoxy-thiophosphorylthio) succinate	Malaoxon
Parathion	O,O-diethyl O-4-nitrophenyl phosphorothioate	Paraoxon-ethyl
Parathion-methyl	O,O-dimethyl O-4-nitrophenyl phosphorothioate	Paraoxon-methyl
Phorate	O,O-diethyl S-ethylthiomethyl phosphorodithioate	Phorate oxygen analog
Phosmet	O,O-dimethyl S-phthalimidomethyl phosphorodithioate	Phosmet oxon
Methidathion (Supracide)	S-2,3-dihydro-5-methoxy-2-oxo-1,3,4-thiadiazol-3-ylmethyl O,O-dimethyl phosphorodithioate	
Profenofos	O-4-bromo-2-chlorophenyl O-ethyl S-propyl phosphorothioate	
Sulprofos (Bolstar)	O-ethyl O-4-(methylthio)phenyl S-propyl phosphorodithioate	
Terbufos	S-tert-butylthiomethyl O,O-diethyl phosphorodithioate	Terbufos-O-analogue sulfon
Dimethoate	O,O-dimethyl S-methylcarbamoylmethyl phosphorodithioate	

PESTICIDE	IUPAC NAME	DEGRADATES
Ethion	O,O,O,O-tetraethyl S,S-methylene bis(phosphorodithioate)	Ethion monoxon
Fenamiphos	ethyl 4-methylthio-m-tolyl isopropylphosphoramidate	Fenamiphos sulfone, Fenamiphos sulfoxide
Tebupirimphos (phostebupirim)		Tebupirimphos oxygen analog
Dicrotophos	3-dimethoxyphosphinoyloxy-N,N-dimethylisocrotonamide	
fenthion	O,O-dimethyl O-4-methylthio-m-tolyl phosphorothioate	Fenthion sulfone, Fenthion sulfoxide
Isofenphos	O-ethyl O-2-isopropoxycarbonylphenyl isopropylphosphoramidothioate	
Temephos	O,O,O,O-tetramethyl O,O-thiodi-p-phenylene diphosphorothioate	
Tribufos	S,S,S-tributyl phosphorotrithioate	
Propetamphos	(E)-O-2-isopropoxycarbonyl-1-methylvinyl O-methyl ethylphosphoramidothioate	
Dichlorvos	2,2-dichlorovinyl dimethyl phosphate	
Sulfotep	O,O,O,O-tetraethyl dithiopyrophosphate	

Ancillary data were also collected for each site to obtain information on watershed properties, water treatment information, and reservoir characteristics. The major cropping patterns in each reservoir watershed are shown in Table III.E.3.2.

Table III.E.3.2: List of Major Crops in Watersheds of Selected Reservoirs in the Reservoir Monitoring Study

State	Cropping Pattern
MO	Not available
TX	Cotton
OH	Corn / soybeans
OK	Not available
CA	Urban / Suburban
IN	Corn / soybeans
SD	Not available
SC	Peach orchards
NC	Tobacco, peanuts
NY	Corn / soybeans
PA	Corn / soybeans

b. Uncertainties and Limitations in Interpreting of Monitoring Data

Some of the uncertainties and limitations associated with interpretation of the reservoir monitoring data are as follows:

- ☐ The samples are not truly paired because sampling did not account for the travel time of the pesticide and its transformation products through the water treatment plant. This may limit stoichiometric linkage of pesticide degradation and formation of degradation products during water treatment. However, comparisons of pesticide concentrations in raw and finished drinking water are possible because temporal variability of pesticide concentrations is expected to be lower in drinking water derived from reservoirs. Additionally, water samples were taken on the same time scale (hours) as the water treatment cycles for the water utilities.
- ☐ OP pesticides had low recoveries in matrix-spiked finished water samples (Personal Communication with Joel Blomquist, USGS, April 28, 2000), which may be associated with their low stability in finished water. Oxidative transformation products of OP pesticides, such as fenamiphos sulfone and sulfoxide and tebupiriamphos oxygen analog, had higher matrix spike recoveries in treated water than the parent compound. Available data indicate OP compounds are not stable in chlorinated drinking water (Magera, 1994, Tierney, et al. 2001, US EPA, 2000). Because OP pesticides generally have lower concentrations in finished water samples, the detection of any OP pesticide in finished water can be viewed as a reliable detection.
- ☐ Ancillary data on weather, pesticide use, and watershed vulnerability need to be considered when interpreting occurrence data. Sampling was extended through 2000 because of extreme drought conditions in the northeastern United States and California during the 1999 sampling season. A lower than average rainfall may have impacted pesticide runoff and resulted in fewer detections of pesticides.

c. Methods of Data Analysis

Scientists in the Office of Pesticide Programs (OPP) of EPA analyzed the reservoir monitoring data for the organophosphorus compounds detected in raw and treated waters. In this analysis, reservoir ("outfall") samples were not considered. Summary statistics were generated only for those OP compounds in the cumulative OP assessment (Attachment III.E.1).

Data from the USGS/EPA Reservoir Monitoring Study (Joel Blomquist, 6/11/01, Written Communication) were reformatted in an EXCEL spreadsheet to accommodate formatting requirements for Statistical Analysis Systems (SAS is a Trademark of SAS Institute, Inc., Cary NC.). Sampling dates in the original data set were modified to facilitate translation of date

variables. After the modification, EXCEL data sets for USGS schedules 2001, 9060, and 9002 were merged into a common data set using a SAS program. Working with USGS, EPA scientists conducted quality assurance and quality control (QA/QC) programs on the data set to eliminate replicated data or modified data. Each data analysis process is described below.

i. Summary Statistics

The Statistical Analysis Systems (SAS) procedures FREQ and SUMMARY calculated detection frequencies and mean detectable concentrations. Concentration distributions (percentiles) were estimated for OP compounds with 10 or more detections in a reservoir during 1999 and 2000. Only diazinon and malaoxon met the criteria for percentile calculations. Percentiles were computed by two different methods for evaluating non-detects. In Method 1, the detection limit was used as a concentration measurement, while in Method 2, non-detects were set equal to zero. This difference does not apply to the computation of mean detected and maximum detected concentrations. Percentiles were computed by linear interpolation using ©SAS proc univariate (percentile Definition 1). Ranked non-time weighted percentile concentrations were reported for all OP pesticides detected in raw or finished water samples (Blomquist et al., 2001). Annual time weighted mean (TWM) concentrations were calculated for the OP pesticides using the limit of detection (LOD) or zero for non-detections to provide bounding estimates of the TWM.

ii. Considering the Impact of Water Treatment

An analysis of water treatment effects was conducted by further modifying the merged data set to calculate the impact of water treatment on pesticide removal or transformation. In this analysis, all samples with nondetects in both raw and finished water samples were removed, while samples with at least one detection were retained in the database. For those samples with one detection, the non-detection was modified to one-half the limit of detection (LOD). This data manipulation was required to allow calculation of water treatment reduction percentages.

Minimum, median and maximum water treatment reduction percentages were determined for paired raw and finished water samples for each pesticide. Water treatment reduction percentages were estimated using the equation $[(\text{raw-finished}/\text{raw}) * 100]$. These percentages, though, can only be estimated when pesticides are detected in both raw and finished water samples. In this reservoir monitoring study, most organophosphorus insecticides were detected only in raw water samples or in finished water samples. In order to allow estimation of water treatment reduction factors, non-detections in raw or finished water samples were assumed to be equal to one-half the LOD. Negative

values are calculated for samples where finished water concentrations were higher than raw water concentrations. This situation can occur when detection limits or frequencies are low.

d. Study Methods and Design

i. Chemical Analytical Methods

The reservoir study used three analytical methods: 2001, 9002, and 9060. Method 2001 used a C-18 solid phase extraction and gas chromatography/ mass spectrometry (GC/MS) (Zaugg et al., 1995). This method has been approved and validated for use in the National Water Quality Assessment (NAWQA) program. Methods 9002 and 9060 were under development and validation during the course of the study, but are now currently approved by USGS. Method 9002 (now referred to as method 2002) used a C-18 solid phase extraction and GC/MS (Sandstrom et al., 2001). Method 9060 (now referred 2060) used solid phase extraction and high performance liquid chromatography/mass spectrometry (HPLC/MS) (Furlong et al., 2001). These methods were used to expand information on occurrence of pesticides and degradation products. Because methods 9002 and 9060 were under development and validated during the monitoring study, the data for these methods are considered as provisional by the USGS.

ii. Quality Assurance and Quality Control Assessment

As requested by OPP, USGS assessed quality assurance and quality control (QA/QC) data for OP pesticides and their degradation products (written communication from Blomquist, J. 5/17/02). The QA/QC assessment was conducted for method 2001 and the provisional method 9002 because these methods were used for chemical analysis of the OP pesticides. The QA/QC assessment is based on laboratory fortified samples in reagent grade water samples and fortified matrix raw and finished drinking water samples. All pesticides were fortified in matrix samples at a concentration of 0.1 ug/L. The percent recoveries were calculated by adjusting for actual sample volume and ambient concentration of analyte in non-fortified samples.

The average analyte-matrix contact time was variable for the fortified matrix samples. In general, matrix samples for method 2001 were fortified in the field, shipped to the National Water Quality Laboratory (NWQL), and then extracted within 1-7 days. The matrix samples for method 9002 were fortified at the NWQL. Recoveries from raw and finished waters were analyzed separately because of expected differences in matrix effects. Statistical analyses of analytical recoveries were conducted using a parametric Cochran t-test or a non-parametric Kruskal-Wallis test.

Mean analytical recovery of OP pesticides in fortified raw water matrix samples ranged from 70% to 175% for 11 compounds for method 2001 and from 30% to 115% for 31 compounds for provisional method 9002 (Table III.E.3.3). Azinphos-methyl and disulfoton sulfone had the highest mean analytical recoveries in raw water matrix samples. Dichlorvos had the lowest mean analytical recovery in raw water matrix samples. Mean analyte recoveries in finished water matrix samples ranged from 4% to 55% for method 2001 and 3% to 135% for provisional method 9002. Disulfoton and phorate oxon had the lowest mean analytical recovery in finished water matrix samples, while tebupirimphos oxygen analog had the highest mean analytical recovery in finished water samples.

Statistical analysis indicates median analytical recoveries in finished water matrix were significantly lower than recoveries in raw matrix samples for method 2001. A similar observation was found for 19 organophosphorus pesticides in method 9002. Diclorvos and tebupiramphos, however, had significantly higher ($P=0.05$) median recoveries in finished water when compared to raw water matrix samples. Chlorpyrifos oxygen analog, fenamiphos sulfone, fenamiphos sulfoxide, phosmet oxon, and terbufos-O-analogue sulfone had similar median recoveries between raw water matrix samples and finished water matrix samples.

Table III.E.3.3: Mean recoveries of fortified laboratory set and matrix samples for OP pesticides from USGS methods 2001 and 9002 (decimal percentage).

Chemical	Lab Set 1999	Lab Set 2000	Raw Matrix	Finished Matrix
Azinphos methyl§	0.81±0.39 (108)	0.86±0.34 (422)	1.75±0.53 (33)	0.38±0.64 (30)
Azinphos-methyl-oxon§	0.48±0.20 (163)		0.85±0.29 (32)	0.55±0.32(28)
Chlorpyrifos§	0.90±0.14 (108)	0.90±0.10 (422)	1.00±0.28 (34)	0.21±0.35 (31)
Chlorpyrifos, oxygen analog	0.40±0.20 (163)		0.44±0.34 (32)	0.59±0.37 (28)
Diazinon§	0.91±0.15 (108)	0.93±0.11(422)	1.09±0.26 (34)	0.26±0.43 (31)
Diclorvos§	0.43±0.16 (163)		0.30±0.22 (34)	0.46±0.24 (28)
Dicrotophos	0.27±0.08 (163)		0.34±0.11 (30)	0.30±0.14 (28)
Dimethoate§	0.39±0.11 (163)		0.57±0.13 (30)	0.05±0.15 (28)
Disulfoton§	0.83±0.18 (108)	0.76±0.14 (422)	0.70±0.30 (34)	0.04±0.16 (31)
Disulfoton sulfone§	0.78±0.14 (163)		1.06±0.24 (32)	0.15±0.33 (28)
Disulfotone sulfoxide§	1.12±0.35 (163)		1.15±0.44 (30)	0.18±0.47 (28)
Ethoprop§	0.94±0.17 (108)	0.86±0.13 (422)	1.07±0.26 (34)	0.55±0.41 (31)
Ethoprop metabolite 76960§	0.80±0.33 (28)		0.95±0.23 (32)	0.80±0.33 (28)
Fenamiphos§	0.62±0.11 (163)		1.09±0.21 (30)	0.04±0.20 (28)

Chemical	Lab Set 1999	Lab Set 2000	Raw Matrix	Finished Matrix
Fenamiphos sulfone	0.63±0.17 (163)		1.12±0.27(30)	1.13±0.46 (28)
Fenamiphos sulfoxide	0.30±0.21 (163)		0.37±0.24 (30)	0.27±0.27 (28)
Malaoxon	1.03±0.41 (28)		1.04±0.29 (32)	1.03±0.41 (28)
Malathion§	0.95±0.19 (108)	0.92±0.14 (422)	1.16±0.36 (34)	0.19±0.33 (31)
Methiathion§	0.19±0.36 (28)		1.15±0.31 (30)	0.19±0.36 (28)
Paraoxon-methyl§	0.86±0.35(28)		0.79±0.26 (32)	0.86±0.35 (28)
Parathion-methyl§	0.82±0.20 (108)	0.95±0.14 (422)	1.29±0.40 (34)	0.31±0.52 (31)
Phorate§	0.79±0.14 (108)	0.81±0.14 (422)	0.77±0.27 (34)	0.04±0.16 (31)
Phorate Oxygen-Analog§	0.03±0.15 (28)		0.97±0.26 (32)	0.03±0.15 (28)
Phosmet	0.07±0.15 (28)		0.40±0.30(30)	0.07±0.15 (28)
Phosmet Oxon	0.49±0.43 (28)		0.37±0.30 (30)	0.49±0.43 (28)
Tebupirampfos§	0.19±0.33 (28)		0.98±0.10 (30)	0.19±0.33 (28)
Tebupirampfos oxygen analog§	Not Available		1.01±0.22 (32)	1.35±0.48 (28)
Terbufos§	0.80±0.15 (108)	0.81±0.11 (422)	0.88±0.22 (34)	0.05±0.18 (31)
Terbufos-O-analogue sulfone	1.07± 0.69 (28)		1.12±0.65 (30)	1.07±0.69 (28)
Tribuphos§	Not Available		0.85±0.12 (30)	0.59±0.27 (28)

()- Number of samples used for mean and standard deviation

§- Indicates significant difference (P<0.05) in median recoveries from raw water and finished water samples

Azinphos-methyl had significantly (P=0.05) higher analytical recoveries in raw water matrix samples than laboratory set samples (Table III.E.3.3). Disulfoton had significantly (P=0.05) lower mean recoveries in raw water matrix samples compared to laboratory set samples. Raw water matrix-enhanced recovery also was found for chlorpyrifos, diazinon, ethoprop, malathion, parathion-methyl, and terbufos. Matrix enhanced recoveries have been found through quality control analysis for National Water Quality Assessment Program (Martin, 1999).

Azinphos-methyl oxon and dicrotophos had significantly higher (P<0.05) mean recoveries in raw water matrix sample compared to the laboratory set recoveries, chlorpyrifos oxygen analog had significantly higher (P=0.05) mean recoveries in finished water compared to laboratory recoveries. There were no significant (P<0.05) differences in recoveries of chlorpyrifos oxygen analog and disulfotone sulfoxide from raw matrix samples and laboratory set samples.

In summary, the OP pesticides and their degradation products in the cumulative OP assessment generally had similar or enhanced recovery in

the matrix samples compared to the laboratory set samples. However, parent OP pesticides had lower recoveries in finished water matrix samples compared to laboratory set samples. OP degradation products generally had similar or higher recoveries in finished water matrix samples.

iii. Water Treatment Trains and Basic Water Quality Data

Although the water quality parameters, including pH, hardness, and total organic carbon, varied among the 12 reservoirs (Table III.E.3.4), the physical construct of the treatment train processes was similar.

Source Water ⇒ Screens ⇒ Prechlorination (Preoxidation) ⇒ Rapid Mixer ⇒ Flocculation ⇒ Filtration ⇒ Post Disinfection ⇒ Clearwell

Table III.E.3.4: Average Water Quality Parameters for Raw Water at Candidate Reservoirs

Water Systems	Average Flow Through Time (hours)	Water Quality Properties			
		pH	Alkalinity (mg/L as CaCO ₃)	Hardness (mg/L as CaCO ₃)	TOC* (mg/L)
MO	26	7.9 to 9.2	63-120	90 - 145	4.7
TX	10	7.7	100	108	4-8
OH	23	7.7	95	126	5.2
OK	NA	7.9-8.8	137	150	5.8
CA	3.25	7.5	91	250	6-8
IN	8.75	8.2	128	200	4
SD	12-13	9.2	32	NA	NA
SC	4	6.9	17	15	3.8
NC	NA	7	12	NA	NA
LA	NA	NA	NA	NA	NA
NY	0.29	7.8-9.0	40-100	140	4.4
PA	7-9	7.2	7.2	172	2-3

NA-Not available

* TOC= Total Organic Carbon

The average water flow-through time at each treatment plant was less than 24 hours. The most common treatment practices included prechlorination and post disinfection, coagulation, and pH adjustment processes. Chlorine and chlorine dioxide were the most common disinfectants used in the prechlorination process (Table III.E.3.5), while chlorine and chloramines were the most common disinfectants used in the post disinfection process. The most common coagulants used in the treatment trains were aluminum salts and polymers. The data also shows

that pH was adjusted by adding lime and sodium hydroxide. Several of the treatment plants used activated carbon in the treatment train. Powdered activated carbon was used as part of the pre-disinfection process in the PA, NY, SC, IN water utilities, while granular activated carbon was used prior to the post disinfection process at the MO, OK, and OH water utilities.

Table III.E.3.5: Treatment trains for utilities in the reservoir monitoring program

State	Treatment Train
MO	(1) Prechlorination with Chlorine Dioxide → (2) Flash Mixer + polymer coagulant → (3) Flocculation/Sedimentation + Lime → (4) Flash Mixer + Sodium silica fluoride → (5) Flocculation/ Sedimentation + Chlorine → (6) Dual Media Filtration + sand with GAC cap → (7) Chlorine added → (8) Clearwell → (9) Distribution
TX	(1) Prechlorination with Chlorine + KMnO ₄ → (2) Flocculation + Iron salts (ferric sulfate)/pH adjustment (caustic soda) → (3) Filtration- dual media sand/ anthracite → (4) Post-Disinfection with chloramines → (5) Corrosion control- pH adjustment/ fluorosilic acid
OH	1) Prechlorination with Chlorine Dioxide (ClO ₂) + KMnO ₄ → (2) Rapid Mix + Aluminum → (3) Flocculation + pH adjustment/ polymers → (4) Settling → (5) Filtration (Rapid sand with GAC) → (6) Post-Disinfection (phosphate/ fluoride/chlorine and caustic soda) → (7) Clearwell → (8) Distribution
OK	(1) Aeration → (2) Prechlorination with ozone → (3) Flocculating/ Clarifier + polymer/ Lime → (4) Solids contact/ clarifier + carbon dioxide → (5) Post-Disinfection with ozone → (6) Polyphosphate polymer + chlorine → (7) Mixed media filters- multimedia → (8) Carbon filter- GAC → (9) Post-Disinfection with chlorine → (10) Clearwell → (11) Distribution
CA	(1) Prechlorination with chlorine (optional)/ aluminum salts → (2) Rapid Mix/ Cationic polymer → (3) Accelerator + chlorine (optional)/ non-ionic polymer → (4) Pre-chlorination + NaOH → (5) Dual media filters → (6) Post-chlorination → (7) Clearwell → (8) Holding pond
IN	(1) Prechlorination with chlorine + carbon and KMnO ₄ → (2) Splitter and Rapid Mix + chlorine, aluminum sulfate, polymer, carbon, ammonia, lime, and KMnO ₄ → (3) Mixing and settling basin + chlorine, polymer, and carbon added → (4) Filter plant → (5) Fluoride added → (6) Finished water reservoir + chlorine → (7) Distribution
SD	(1) GAC polymers → (2) Lime, aluminum sulfate, polymers added → (3) Chlorine dioxide, carbon dioxide, and fluoride added → (4) Ammonium polyphosphate → (5) Chlorine added
SC	(1) Prechlorination with chlorine + liquid alum, lime, carbon, and polymer → (2) Hydraulic flocculators + aluminum salts, polymers → (3) Dual media High Rate Filters → (4) Post-Disinfection with chlorine + fluoride, lime, and phosphate → (5) Clearwells → (6) Distribution pumps
NC	(1) Prechlorination + aluminum salts and pre-caustic → (2) Flash Mixer + polymer Flocculator → (3) Sedimentation basin + chlorine → (4) Dual media filter → (5) Post-disinfection with chlorine + post caustic, fluoride, chlorine, and phosphate → (6) Clearwell → (7) Distribution system
NY	(1) Prechlorination with chlorine + KMnO ₄ / PAC → (2) Flocculation + aluminum salts/ polymers → (3) Filtration - rapid sand and mixed media → (4) Post-Disinfection with chlorine + fluoride + ortho phosphate → (5) Clearwell → (6) Storage → (7) Distribution

State	Treatment Train
PA	(1) Prechlorination with chlorine dioxide + PAC + KMnO ₄ + lime → (2) Flocculation/clarification + aluminum sulfate → (3) Filtration with sand/ anthracite + hydrofluorisisilic acid → (3) Ammonium sulfate + chloramines → (4) Corrosion control + phosphate → (5) clearwell → (6) Reservoir → (7) Distribution

e. Summary of Organophosphorus Detections

The pilot reservoir monitoring study provided two years of raw (525 samples) and finished (249 samples) water occurrence data for 18 active OP parent compounds and 13 transformation products considered in the cumulative OP assessment. This pilot program included OP pesticides that have not been analyzed in most other monitoring studies, such as tribufos, phostebupirim, profenofos and dichlorvos, and some rarely analyzed transformation products.

Of the thirteen OPs detected in either raw or finished drinking water samples, diazinon was, by far, the most frequently detected compound. Although it was found in 35% of 323 raw water samples (Table III.E.3.6), it was not found in 227 finished water samples, suggesting that this pesticide was reduced or transformed by water treatment processes. Unfortunately, the likely transformation product, diazoxon, was not analyzed in the USGS schedules to substantiate that it was found in treated water.

Other OPs and their oxygen analogs also followed a similar pattern of detection, but the number of detections was not sufficient to formulate any definite conclusions. For instance, malathion was detected in 6 of 323 raw water samples (2%), while malaoxon was detected in 11 of 220 finished water samples (5%). It is important to note that three finished and raw water samples (LA water utility on August 26, 1999; September 8, 1999 and June 7, 2000) showed the presence of only malathion in raw water and malaoxon in finished water. In this situation, malathion may have transformed into malaoxon during the treatment process. Chlorpyrifos was detected in 5% of raw water samples, but neither chlorpyrifos nor its oxygen analog were detected in finished water. Azinphos-methyl and its oxon were both found in raw and finished water. In this study, though, the difference between the number of detections for each was not enough to allow statistical quantification of treatment effects, especially since azinphos methyl and its oxon were only found in the MO water utility.

Some non-persistent parent OP pesticides, such as fenamiphos and disulfoton, were not detected in raw and treated water. However, their longer-lived sulfoxide and sulfone transformation products were detected in raw and finished water samples. The low detection frequencies (<1% or 2 samples) in raw and finished water samples limited a clear quantitative assessment of treatment transformation.

Table III.E.3.6: Summary statistics for organophosphorus pesticides and their degradation products

Chemical	LOD	Raw					Finished				
		No. samples	No. detects	% Detected	Max. ug/L	Mean ug/L	No. samples	No. detects	% Detected	Max. ug/L	Mean ug/L
Azinphos-methyl-oxon	0.031	316	1	0.3%	0.263	0.263	219	4	1.8%	0.026	0.018
Azinphos-methyl	0.001	321	8	2.5%	0.144	0.077	225	5	2.2%	0.114	0.059
Chlorpyrifos	0.004	323	17	5.3%	0.034	0.006	227	.	.	.	.
Chlorpyrifos, oxygen analog	0.016	316	.	.	.	.	220	.	.	.	.
Diazinon	0.002	323	114	35%	0.101	0.023	227	.	.	.	.
Diclorvos	0.005	316	.	.	.	.	220	.	.	.	.
Dicrotophos	0.016	316	.	.	.	.	220	.	.	.	.
Dimethoate	0.005	316	4	1.3%	0.022	0.012	220	.	.	.	.
Disulfoton	0.017	323	.	.	.	.	227	.	.	.	.
Disulfoton sulfone	0.005	316	1	0.3%	0.013	0.013	220	.	.	.	.
Disulfotone sulfoxide	0.016	316	1	0.3%	0.006	0.006	220	.	.	.	.
Ethoprop	0.003	323	.	.	.	.	227	.	.	.	.
Ethoprop metabolite 76960	0.005	316	.	.	.	.	220	.	.	.	.
Fenamiphos	0.016	316	.	.	.	.	220	.	.	.	.
Fenamiphos sulfone	0.008	316	1	0.3%	0.005	0.005	220	2	0.9%	0.016	0.012
Fenamiphos sulfoxide	0.031	316	2	0.6%	0.033	0.021	220	1	0.5%	0.022	0.022
Malaoxon	0.016	316	.	.	.	.	220	11	5.0%	0.556	0.106
Malathion	0.005	323	6	1.9%	0.106	0.032	227	.	.	.	.
Methidathion	0.008	316	1	0.3%	0.01	0.01	220	.	.	.	.
Paraoxon-methyl	0.031	316	.	.	.	.	220	.	.	.	.
Parathion-methyl	0.006	323	1	0.3%	0.061	0.061	227	.	.	.	.
Phorate	0.002	323	.	.	.	.	227	1	0.4%	0.001	0.001
Phorate oxygen analog	0.031	316	.	.	.	.	220	.	.	.	.
Phosmet	0.008	316	.	.	.	.	220	.	.	.	.
Phosmet oxon	0.016	316	.	.	.	.	220	.	.	.	.
Profenofos	0.008	316	.	.	.	.	220	.	.	.	.
Tebupiramphos (Phostebupirim)	0.016	316	.	.	.	.	220	.	.	.	.
Terbufos-O-analog sulfon	0.016	316	.	.	.	.	220	2	0.9%	0.015	0.012
Terbufos	0.013	323	.	.	.	.	227	.	.	.	.
Tribufos (DEF, s,s,s-Tr)	0.016	316	.	.	.	.	220	.	.	.	.
tebupiramphos oxygen analog	0.008	316	3	0.9%	0.007	0.005	220	.	.	.	.

(1) LOD = Limit of Detection. The value reported is the most common limit of detection. For some chemicals, the LOD varied during method development.

Diazinon was detected in 10 of 12 reservoirs, and chlorpyrifos was detected in 6 reservoirs, reflecting their widespread use (Table III.E.3.7). The maximum concentration of diazinon was 0.045 ug/L in the raw water of the CA treatment plant. Percentile concentrations of diazinon for the combined 1999 and 2000 sampling season are shown in (Table III.E.3.8). The distribution of diazinon concentrations in raw intake water suggest that the detected concentrations of diazinon were roughly representative of percentile concentrations greater than the 50th percentile. The estimated concentration percentiles were relatively insensitive to the values assumed (either the detection limit or zero) for non-detected samples.

Table III.E.3.7: Summary statistics for water type, year, and water utility (ug/L)

Chemical	State	Year	Water type	Non-detects		Conc. Estimated		Conc. Measured	
				Samples	LOD Range	Samples	Range	Samples	Range
Azinphos-methyl	MO	2000	Raw	18	0.001-0.05	1	0.034		
	SC	2000	Finished	6	0.001-0.075	5	0.019-0.114		
	SC	2000	Raw	15	0.001-0.1	7	0.029-0.144		
Azinphos-methyl-oxon	MO	2000	Finished	8	0.031	2	0.008-0.01		
	NY	2000	Finished	8	0.31-0.06	2	0.026		
	OK	1999	Raw	20				1	0.263
Chlorpyrifos	LA	1999	Raw	8				3	0.005-0.008
	MO	2000	Raw	18	0.004-0.005			1	0.034
	OH	2000	Raw	8	0.004	2	0.002-0.004		
	OK	1999	Raw	20	0.004	1	0.002		
	OK	2000	Raw	19	0.004-0.005			1	0.004
	PA	2000	Raw	6	0.004-0.006	2	0.003	3	0.004-0.012
	SC	2000	Raw	20	0.004-0.005	4	0.002		
Diazinon	CA	1999	Raw	1	0.002			7	0.004-0.045
	IN	1999	Raw	28	0.002-0.01	5	0.003-0.004	4	0.004-0.006
	IN	2000	Raw	1	0.002	1	0.005	9	0.006-0.01
	LA	2000	Raw	10	0.002-0.006			1	0.01
	MO	1999	Raw	7	0.002-0.01			14	0.005-0.022
	NC	1999	Raw	5	0.002	2	0.003-0.004	3	0.004-0.012
	OH	1999	Raw	10	0.002	1	0.003		
	OH	2000	Raw	1	0.002			9	0.008-0.015
	OK	1999	Raw	1	0.002			20	0.017-0.101
	OK	2000	Raw					20	0.012-0.095
	PA	1999	Raw	11	0.002			1	0.006
	PA	2000	Raw	5	0.002	1	0.002	5	0.005-0.015
	SC	1999	Raw	20	0.002	1	0.002		
	SC	2000	Raw	20	0.002-0.005	4	0.001-0.003		
	TX	1999	Raw	16	0.002-0.006	5	0.003-0.004	1	0.004
Dimethoate	LA	1999	Raw	8	0.005			1	0.007
	PA	2000	Raw	8	0.005	1	0.006	2	0.012-0.022
Disulfoton sulfone	NY	2000	Raw	9	0.005			1	0.013
Disulfoton sulfone sulfoxide	NY	2000	Raw	9	0.016	1	0.006		
Fenamiphos sulfone	NC	1999	Finished	8	0.008	1	0.007	1	0.016
	NC	1999	Raw	9	0.008	1	0.005		
Fenamiphos sulfoxide	IN	2000	Finished	10	0.031	1	0.022		
	IN	2000	Raw	10	0.031			1	0.033
	MO	2000	Raw	17	0.031	1	0.008		
Malaoxon	LA	1999	Finished	7	0.016			3	0.052-0.204
	LA	2000	Finished	3	0.016	3	0.008-0.01	5	0.019-0.556
Malathion	LA	1999	Raw	8	0.005			3	0.023-0.106
	LA	2000	Raw	9	0.005-0.027			2	0.008-0.011
	MO	2000	Raw	18	0.005-0.027			1	0.007
Methidathion	MO	1999	Raw	19	0.008			1	0.01
Parathion-methyl	LA	1999	Raw	10	0.006			1	0.061
Phorate	MO	2000	Finished	13	0.002-0.011	1	0.001		
Terbufos-O-analogue sulfon	PA	2000	Finished	9	0.016	2	0.009-0.015		
tebupiramphos (Phostebupirim)	MO	1999	Raw	18	0.008	2	0.003-0.007		
	PA	1999	Raw	12	0.008	1	0.006		

(1) Estimated concentrations are qualified estimate of concentration. This is defined as: Compounds with low or high recoveries (for example, USGS analytical schedule 9002-outside the range of 60 to 120% recovery) or concentrations lower than the laboratory reporting limit.

Table III.E.3.8: Concentration percentiles for diazinon in raw water samples

State	No.	Detected	mean (ug/L)	percentile method	Percentiles (ug/L)					max detected (ug/L)
					50th	75th	80th	90th	95th	
California	8	7	0.017		[not computed for <10 detections]					0.045
Indiana	48	19	0.0059	1	0.002	0.005	0.0060	0.0082	0.0096	0.010
				2	0.000	0.005	0.0054	0.0072	0.0090	
Louisiana	22	1	0.010		[not computed <10 detections]					0.010
Missouri	40	14	0.0099	1	0.002	0.0060	0.0080	0.011	0.013	0.022
				2	0.000	0.0060	0.0070	0.011	0.013	
N. Carolina	10	5	0.0068		[not computed <10 detections]					0.012
New York	22	0								
Ohio	21	10	0.0102	1	0.002	0.0088	0.011	0.013	0.013	0.015
				2	0.000	0.0088	0.011	0.013	0.013	
Oklahoma	41	40	0.0505	1	0.051	0.066	0.072	0.080	0.087	0.10
				2	0.051	0.066	0.072	0.080	0.087	
Penn.	23	7	0.0076							0.015
S. Carolina	45	5	0.0018		[not computed <10 detections]					0.0030
S. Dakota	21	0								
Texas	22	6	0.0035							0.0040

Of the parent OP compounds, diazinon and chlorpyrifos were the only ones detected in more than three reservoirs while azinphos-methyl had the highest detected concentration (0.114 ug/L in South Carolina raw water). It also had a high detection frequency (32-46%) in raw and finished water samples in the SC reservoir. Azinphos-methyl oxon was not detected in raw or finished water from the SC reservoir. The precision of azinphos-methyl and azinphos methyl-oxon concentrations, though, is low because the detections were estimated at concentrations near the reported detection limit. Analytical detection limits varied among the OP pesticides and their transformation products (Attachment III.E.2). In general, the lowest detection limit was the most commonly reported detection limit.

Malaoxon had the highest concentration of all 31 OP analytes, with maximum finished-water concentrations in Louisiana of 0.556 ug/L in 2000, and 0.204 ug/L in 1999. Malathion concentrations in raw water ranged from 0.023 to 0.106 ug/L in 1999 and 0.008 to 0.011 ug/L in 2000. The percentile concentration of malaoxon in finished water at the LA treatment plant are shown in Table III.E.3.9.

Table III.E.3.9: Concentration percentiles for malaoxon in finished water samples in Louisiana.

Chemical	No. analyzed	No. detects	mean conc.	50th %ile	75th %ile	80th %ile	90th %ile	95th %ile	range of detected conc.
Malaoxon (finished water)	21	11	0.11	below LOD	0.052	0.059	0.12	0.20	0.008 - 0.56
Malathion (raw water)	22	5	0.038	[not computed with fewer than 10 detections]					0.008 - 0.11

Table III.E.3.10 summarizes percentile concentrations for the OP pesticides in raw and finished water. Malaoxon and diazinon were the only compounds with sufficient magnitude and range of detections to allow estimation of median, 90th percentile, and maximum concentrations. In most cases, maximum and 90th percentile concentrations were above the LOD while the 50th percentile concentration was normally below the LOD.

Table III.E.3.10: Concentration percentiles for OP compounds in raw and finished water samples in (ug/L).

Chemical	State	Water Type	Max ³	90th percentile ³	Median ³
Azinphos-methyl	SC	Raw	0.144	0.054	
	SC	Finished	0.114	0.038	
Azinphos-methyl-oxon	NY	Raw	0.026	0.013	
	OK	Raw	0.263		
Chlorpyrifos	LA	Raw	0.008	0.005	
	OH	Raw	0.004		
	OK	Raw	0.004		
	PA	Raw	0.015	0.007	
	SC	Raw	0.002		
Diazinon	OH	Raw	0.015	0.013	
	OK	Raw	0.101	0.08	0.051
	PA	Raw	0.012	0.004	
	SC	Raw	0.003	0.001	
	TX	Raw	0.004	0.004	
	CA	Raw	0.045	0.045	0.015
	IN	Raw	0.01	0.008	
	LA	Raw	0.01		
	MO	Raw	0.022	0.011	
	NC	Raw	0.012	0.011	0.001
Dimethioate	LA	Raw	0.007		
	PA	Raw	0.022	0.006	
Disulfoton sulfone	NY	Raw	0.013		
Disulfoton sulfoxide	NY	Raw	0.006		
Fenamiphos sulfone	NC	Raw	0.005	0.002	
	NC	Finished	0.016	0.011	
Fenamiphos sulfoxide	IN	Raw	0.033		
	MO	Raw	0.008		
Malaoxon	LA	Finished	0.556	0.128	0.008
Malathion	LA	Raw	0.106	0.023	
	MO	Raw	0.007		
Methidathion	MO	Raw	0.01		
Parathion-methyl	LA	Raw	0.061		
Phorate	MO	Finished	0.001		
Tebupiramphos	MO	Raw	0.007		
	PA	Raw	0.006		
Terbufos-O-analogue sulfone	PA	Finished	0.015		

Percentile concentrations are taken from Blomquist et al., 2000.

Time-weighted mean concentrations (TWM) for OP pesticides and their degradation products were low in raw and finished waters (Table III.E.11). Diazinon had the highest TWM (0.059 ug/L) in raw water while malaoxon had

the highest TWM (0.043 ug/L) in finished water. In general, the bounding estimates of TWM was dependent on the treatment of non-detections in the calculation of TWM. The use of zero for non-detections led to TWM concentrations below the LOD.

Table III.E.3.11: Time weighted annual means (TWM) for OP compounds in raw and finished water samples in (ug/L).

OP	State	Year	Range LOD	Raw TWM (DL)	Raw TWM(0)	Finished TWM(DL)	Finished TWM(0)
azinphos-methyl	SC	1999	0.001-0.10	0.001	0.000	0.001	0.000
		2000		0.051	0.017	0.029	0.009
azinphos-methyl-oxon	MO	1999	0.031-0.31	0.031	0.000	0.024	0.000
		2000		0.031	0.000	0.024	0.000
	NY	1999		0.031	0.000	0.031	0.000
		2000		0.031	0.000	0.031	0.007
	OK	1999		0.035	0.005	0.013	0.000
		2000		0.032	0.000	0.021	0.000
chlorpyrifos	LA	1999	0.004-0.006	0.006	0.004	0.004	0.000
		2000		0.005	0.000	0.004	0.000
	OH	1999		0.004	0.000	0.004	0.000
		2000		0.004	0.001	0.002	0.000
	OK	1999		0.004	0.000	0.002	0.000
		2000		0.004	0.000	0.003	0.000
	PA	1999		0.004	0.000	0.004	0.000
		2000		0.005	0.002	0.004	0.000
	SC	1999		0.004	0.000	0.003	0.000
		2000		0.004	0.000	0.003	0.000
diazinon	OH	1999	0.002 -0.01	0.002	0.000	0.002	0.000
		2000		0.009	0.008	0.002	0.000
	OK	1999		0.055	0.055	0.001	0.000
		2000		0.059	0.059	0.002	0.000
	PA	1999		0.002	0.001	0.002	0.000
		2000		0.004	0.003	0.003	0.000
	SC	1999		0.002	0.000	0.002	0.000
		2000		0.003	0.000	0.002	0.000
	TX	1999		0.002	0.001	0.001	0.000
		2000		0.030	0.030	0.002	0.000
	CA	1999		0.003	0.001	0.002	0.000
		2000		0.006	0.006	0.003	0.000
	LA	1999		0.002	0.000	0.002	0.000
		2000		0.004	0.000	0.002	0.000
	MO	1999		0.005	0.003	0.002	0.000
		2000		0.002	0.000	0.002	0.000
	NC	1999		0.003	0.002	0.002	0.000
dimethioate	LA	1999	0.005	0.004	0.000	0.005	0.000
		2000		0.005	0.000	0.005	0.000
	PA	1999		0.005	0.000	0.005	0.000
		2000		0.006	0.000	0.005	0.000
disulfoton sulfone	NY	1999	0.005	0.016	0.000	0.016	0.000
		2000		0.016	0.000	0.016	0.000
disulfoton sulfoxide	NY	1999		0.005	0.000	0.005	0.000
		2000		0.005	0.000	0.005	0.000
fenamiphos sulfone	NC	1999	0.008	0.008	0.000	0.008	0.000
fenamiphos sulfoxide	IN	1999	0.031	0.031	0.000	0.024	0.000
		2000		0.031	0.001	0.031	0.001
	MO	1999		0.031	0.000	0.024	0.000
		2000		0.025	0.000	0.020	0.000
malaoxon	LA	1999	0.016	0.013	0.000	0.032	0.020
		2000		0.016	0.000	0.043	0.034
malathion	LA	1999	0.005-0.027	0.016	0.012	0.005	0.000
		2000		0.010	0.001	0.009	0.000
	MO	1999		0.005	0.000	0.004	0.000
		2000		0.009	0.001	0.008	0.000
methidathion	MO	1999	0.008	0.008	0.000	0.006	0.000
		2000		0.007	0.000	0.005	0.000
parathion-methyl	LA	1999	0.006	0.008	0.002	0.006	0.000

OP	State	Year	Range LOD	Raw TWM (DL)	Raw TWM(0)	Finished TWM(DL)	Finished TWM(0)
phorate	MO	2000	0.002-0.011	0.006	0.000	0.006	0.000
		1999		0.002	0.000	0.002	0.000
		2000		0.003	0.000	0.003	0.000
tebupiramphos	MO	1999	0.008	0.008	0.000	0.006	0.000
		2000		0.007	0.000	0.005	0.000
	PA	1999		0.007	0.002	0.008	0.000
		2000		0.008	0.000	0.008	0.000
terbufos-O-analogue sulfone	PA	1999	0.008	0.016	0.000	0.016	0.000
		2000		0.016	0.000	0.016	0.001

*Shaded gray areas indicate TWM concentrations greater than the lowest LOD.

i. Water Treatment Effects

The concentration of most parent OP insecticides (diazinon, chlorpyrifos, malathion, dimethate, methyl parathion) fell below the LOD during water treatment. Furthermore, the oxidative degradation products (azinphos methyl-oxon, fenamiphos sulfoxide, malaoxon, and terbufos-O-analogue sulfone) were detected more frequently in finished water than in raw water. Several degradation products (malaoxon, and terbufos-O-analogue sulfone) were not detected in raw water samples.

In analyzing the effects of water treatment on pesticide concentrations, water treatment reduction percentages were used to quantify the water treatment removal. These percentages, though, can be estimated only when pesticides are detected in both raw and finished water samples (Table III.E.3.12). In this reservoir monitoring study, most OP insecticides were detected only in raw water samples or in finished water samples. In order estimate of water treatment reduction factors, non-detections in raw or finished water samples were assumed to be equal to one-half the LOD. Negative values can occur when detection limits or frequencies are low.

Table III.E.3.12: Water treatment reduction percentages and maximum concentrations in raw and finished water for selected OP pesticides

Pesticide	USGS Schedule	Max Raw Conc ug/L	Max Finish Conc ug/L	Min Percent Reduction	Max Percent Reduction
Azinphos-methyl	2001	0.144	0.114	19	41
Azinphos-methyl-oxon	9002	0.263	0.026	0*(-67)	94
Chlorpyrifos	2001	0.012	0.002	0	83
Diazinon	2001	0.101	0.0025	0*(-150)	99
Dimethoate	9002	0.022	0.0025	58	88
Disulfoton sulfone	9002	0.013	0.0025	----	80

Pesticide	USGS Schedule	Max Raw Conc ug/L	Max Finish Conc ug/L	Min Percent Reduction	Max Percent Reduction
Disulfoton sulfoxide	9002	0.006	0.008	---	0*(-33)
Fenamiphos sulfone	9002	0.005	0.016	0*(-300)	0*(-40)
Fenamiphos sulfoxide	9002	0.033	0.022	---	33
Malaoxon	9002	0.008	0.556	0*(-6850)	0
Malathion	2001	0.106	0.0025	64	97
Parathion-methyl	2001	0.061	0.003	---	95
Phorate	2001	0.001	0.001	---	0
Tebupiriamphos	9002	0.007	0.004	33	42
Terbufos-O-analogue sulfone	9002	0.008	0.015	0*(-87.5)	0*(-12.5)

Equation for pesticide reduction calculation= (raw-finished/raw)*100

0* indicates a negative percent reduction was observed. A negative percent reduction indicates the finished water concentration is greater than the raw water concentration.

—Indicates a single pair of raw and finished water was available.

Table III.E.3.9 shows a wide variability in the water treatment removal efficiencies among organophosphate compounds. Phosphorothioate and phosphorodithiate compounds (chlorpyrifos, diazinon, parathion-methyl, dimethoate) have high maximum water treatment removal percentages (80-99%), while phorate and azinphos-methyl have lower water treatment reduction percentages. These findings are consistent with those reported in the open literature for chlorination effects on organophosphorus insecticide degradation (Magera, 1994, Tierney, et al. 2001, US EPA, 2000).

The reservoir monitoring study shows, that in general, the oxidative degradation products have lower water treatment reduction percentages than their parent compounds. A negative water treatment reduction percentage may indicate that the parent compound is transformed during treatment. For some degradation products, such as malaoxon and terbufos-O-analogue sulfone, chemical transformation is a possible explanation for their occurrence in finished water samples only. For other degradation products, such as azinphos-methyl-oxon, fenaminphos sulfoxide, and fenaminphos sulfone, which were found in both raw and finished water, degradate formation may occur during transport in the watershed or water treatment.

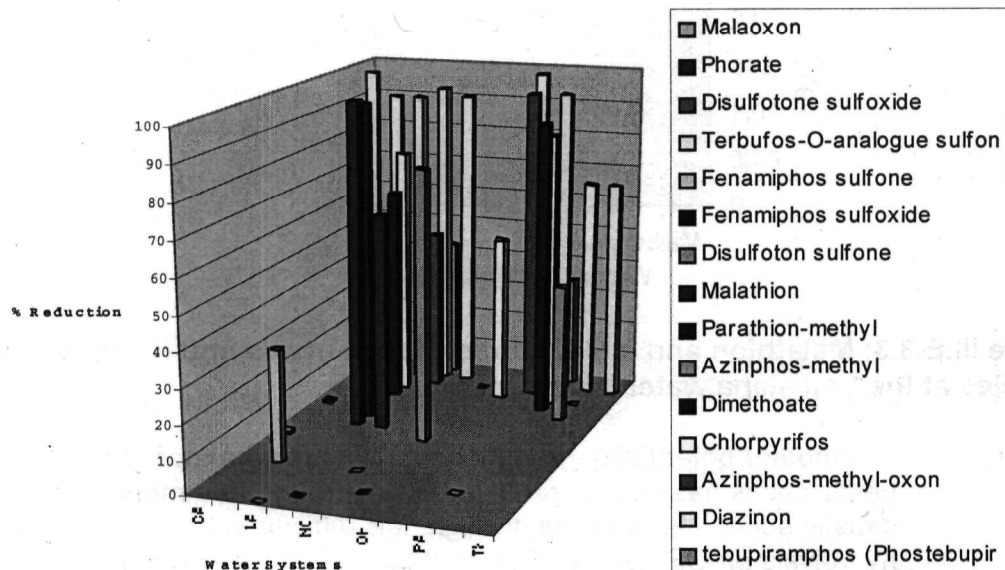


Figure III.E.3.2: Maximum Water Treatment Reduction Percentages Among Reservoirs

Figure III.E.3.2 shows the maximum water treatment reduction efficiencies among the 12 reservoirs that were analyzed in this study. Because individual treatment processes were not evaluated in this study and detections were sporadic, it is difficult to assess the impact of specific water treatment processes on pesticide removal and transformation. Diazinon, which was detected most frequently in the raw water at 10 reservoirs, showed maximum water treatment reduction percentages, ranging from 66-99% among the different water treatment systems. Similar ranges of maximum water treatment reduction percentages were reported for other organophosphorus pesticides. A possible explanation for high water treatment removal efficiency is chemical oxidation to such products as oxons through prechlorination and post-disinfection, which are commonly used processes. Because the diazinon degradation product, diazoxon, was not measured in this study, it is difficult to evaluate any linkage between diazinon degradation and diazoxon formation in finished water samples. However, there were three samples in which malathion was found in raw water and malaoxon was found in finished water at the LA water treatment plant (Figure III.E.3.3). This observation may be explained by chemical oxidation as a result of chlorination.

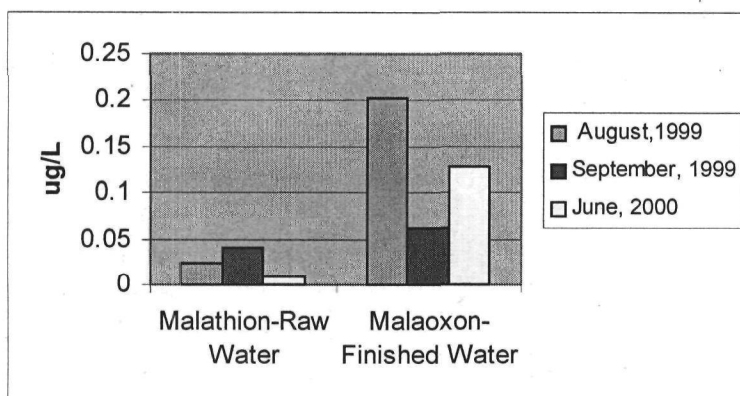


Figure III.E.3.3: Malathion and malaoxon formation in raw and finish water samples at the Louisiana water treatment plant

Another potential degradation pathway of organophosphorus pesticides is base catalyzed hydrolysis through treatment by liming and caustic soda. At this time, though, it is difficult to assess the impact of hydrolysis on OP degradation pathways because information on pH and contact time after pH adjustment were not available for the reservoir monitoring study. In addition, hydrolysis degradation products were not included on the USGS analytical schedules.

ii. Co-occurrence

Co-occurrence of organophosphorus pesticides was found in raw drinking water but not in finished drinking water (Table III.E.13). Twelve percent of the raw samples with OP detections (16 samples from 137 samples) had more than one OP detection. These data suggest that water treatment processes may reduce the occurrence of parent OP pesticides in finished drinking water.

Table III.E.3.13: Co-occurrence frequency of OP pesticides in raw and finish water samples at reservoir water treatment plants

Number of OPs detected per sample	Number of samples (% of samples) with given number of OPs detected			
	Raw water		Finished	
	Samples	%	Samples	%
0	177	56%	194	88.99%
1 or more	137	44%	24	11%
1	121	39%	24	11%
2	12	3.8%		
3	4	1.3%		
Total	314	100%	218	100

Table III.E.3.14 shows the profile of individual co-occurring OP pesticides and degradation products in raw water samples. These co-occurring pesticides include azinphos-methyl oxon, azinphos-methyl, chlorpyrifos, diazinon, dimethoate, fenamiphos sulfone, fenamiphos

sulfoxide, methidathion, and tebupiriamphos, with diazinon co-occurring the most frequently. These results also show that the PA and MO reservoirs had the highest co-occurrences (3 pesticides per sample) among the various reservoirs.

Table III.E.3.14: Co-occurrence profile of organophosphorus insecticides and some transformation products

Sample (State, date)	Azi/oxon	Azinphos	Chlorpyr	Diazino n	Dimeth	Fena/Sn	Fen/Sx	Methidat	Tebupira
IN 7-11-2000				0.010			0.033		
MO 5-17-1999				0.013					E0.007
MO 5-24-1999				0.022					E0.003
MO 7-19-2000		E0.034	0.034				E0.008		
MO 7-6-1999				0.011				0.010	
NC 5-25-1999				0.012		E0.005			
OH 7-6-2000			E0.002	0.009					
OK 6-29-1999	0.263			0.073					
OK 7-6-1999			E0.002	0.066					
OK 8-2-2000			0.004	0.048					
PA 6-29-2000			0.012	0.015	0.022				
PA 7-11-2000			0.008	0.011	0.012				
PA 8-2-2000			0.004	0.005	E0.006				
SC 6-28-2000		E0.042		E0.001					
SC 8-23-2000		E0.144		E0.003					
SC 9-11-2000			E0.002	E0.002					
Explanation: E=estimated concentration. Azi/oxon=Azinphos-methyl oxon; Azinphos=Azinphos-methyl; Chlorpyr(ifos); Dimeth(oate); Fena/Sn=Fenamiphos sulfone; Fen/Sx=Fenamiphos sulfoxide; Methidat(hion); Tebupira(mphos)									

iii. Conclusion

The reservoir monitoring program provided significant information on the occurrence of a wide range of OPs and their transformation products in raw and treated drinking water. The magnitude of detectable concentrations and frequency of detection of most OP compounds and degradation products were generally low in raw and finished waters. Widely used compounds such as chlorpyrifos, diazinon, azinphos methyl, and malathion were detected in raw drinking waters, while degradation products of OP compounds were predominantly found in finished drinking water. The maximum concentration for OP pesticides in water was <0.5 ug/L. The magnitude of time weighted mean (TWM) concentrations were generally similar to the limit of detection (LOD) and highly dependent on the treatment of non-detections.

The reservoir monitoring data suggest that parent OP pesticides are removed or transformed during treatment, possibly by chemical oxidation. Oxidative degradation products of OP pesticides, such as sulfones, sulfoxides, and oxons, were detected in certain finished water samples from actual water treatment plants. At this time, the impact of the individual treatment processes is difficult to assess because of variability among the

treatment plants in terms of water quality factors, sequence of treatment operations, and dosage of applied treatment chemicals.

Attachment III.E.1: 31 OP chemicals analyzed in the USGS Reservoir Monitoring Study and Used in Analyses.

<i>Chemical</i>	
1	Azinphos-methyl
2	Azinphos-methyl-oxon
3	Chlorpyrifos
4	Chlorpyrifos, oxygen analog
5	Diazinon
6	Diclorvos
7	Dicrotophos
8	Dimethoate
9	Disulfoton
10	Disulfoton sulfone
11	Disulfoton sulfoxide
12	Ethoprop
13	Ethoprop metabolite 76960
14	Fenamiphos
15	Fenamiphos sulfone
16	Fenamiphos sulfoxide
17	Malaoxon
18	Malathion
19	Methidathion (Supracide)
20	Paraoxon-methyl
21	Parathion-methyl
22	Phorate
23	Phorate oxygen analog
24	Phosmet (Imidan)
25	Phosmet oxon
26	Profenofos
27	Tebupirampfos (Phostebupirim)
28	Terbufos
29	Terbufos-O-analogue sulfon
30	Tribuphos (DEF, s,s,s-Tr
31	tebupirampfos (Phostebupirim) oxygen analog

Attachment III.E.2: Summary of Reported Detection Limits for Raw, Finished, and Outfall Samples

Limits of detection for nondetects					
Chemical	Detection Limit (ug/L)	Samples reported <DL	Chemical	Detection Limit (ug/L)	Samples reported <DL
Azinphos-methyl	0.0010	555	Ethoprop metabolite 76960	0.0050	603
	0.0100	13	Fenamiphos	0.0160	603
	0.0150	1	Fenamiphos sulfone	0.0080	600
	0.0200	4	Fenamiphos sulfoxide	0.0310	600
	0.0300	2	Malaoxon	0.0160	587
	0.0400	1		0.0320	1
	0.0500	20		0.0380	1
	0.0600	2		0.0410	1
	0.0700	1		0.0420	1
	0.0750	1		0.0470	1
	0.0800	2	Malathion	0.0050	592
	0.0900	1		0.0070	1
	0.1000	2		0.0090	1
				0.0100	3
Azinphos-methyl-oxon	0.0310	587		0.0270	18
	0.0600	1		0.0600	1
	0.0630	7	Methidathion (Supracide)	0.0080	600
Chlorpyrifos	0.0800	1		0.0510	1
	0.0040	575		0.1100	1
	0.0050	19	Paraoxon-methyl	0.0310	603
	0.0060	5		0.0060	621
	0.0100	2	Phorate	0.0020	603
Chlorpyrifos, oxygen analog	0.0160	603		0.0110	18
Diazinon	0.0020	469	Phorate oxygen analog	0.0310	602
	0.0050	17		0.0420	1
	0.0060	3	Phosmet (Imidan)	0.0080	603
	0.0070	1		0.0160	601
	0.0100	2	Phosmet oxon	0.0300	2
Dichlorvos	0.0050	603		0.0080	602
	0.0160	603	Profenofos	0.2700	1
Dicrotophos	0.0160	603		0.0160	603
Dimethoate	0.0050	599	27. Tebupinamphos (Phostebupir)	0.0130	604
	0.0170	604		0.0170	18
Disulfoton	0.0210	18	Terbufos	0.0160	601
				0.0160	603
Disulfoton sulfone	0.0050	602	Terbufos-O-analogue sulfon	0.0160	603
Disulfoton sulfide	0.0160	602		0.0080	599
Ethoprop	0.0030	604	31. tebupiramphos (Phostebupir)		
	0.0050	18			

LITERATURE CITED

Blomquist, J. D., 2001. Transmittal of Preliminary Digital Data Sets From the USGS-USEPA Program "Pesticides in Water-Supply Reservoirs and Finished Drinking Water- A Pilot Monitoring Program." USGS, Baltimore, MD.

Faust, S.D. and O.M. Aly. 1999. Chemistry of Water Treatment. 2nd Ed. Lewis Publishers. Boca Raton, FL.

Larson, R.A. and E.J. Weber. 1994. Reaction Mechanisms in Environmental Organic Chemistry. Lewis Publications. Boca Raton, FL. pp 122-124.

Magara, Y., T. Aizawa, N. Matumoto, and F. Souna. 1994. Degradation of pesticides by chlorination during water purification. Groundwater Contamination, Environmental Restoration, and Diffuse Source Pollution. Water Science and Technology. 30(7):119-128.

Tierney, D.P., B.R. Christensen, and V.C. Culpepper. 2001. Chlorine Degradation of Six Organophosphorus Insecticides and Four Oxons in Drinking Water Matrix. Submitted by Syngenta Crop Protection, Inc. Greensboro, NC. Performed by Syngenta Crop Protection, En-fate, LLC., and EASI Laboratory.

U.S. EPA. 2001. Laboratory Study on Chlorination and Softening Effects on Pesticide Residues in Drinking Water. Work Assignment (1-22) between EFED and ORD.

U.S. EPA, 2000. Progress Report on Estimating Pesticide Concentrations in Drinking Water and Assessing Water Treatment Effects on Pesticide Removal and Transformation: A Consultation. FIFRA Scientific Advisory Panel (SAP), September 29, 2000. <http://www.epa.gov/scipoly/2000/September/sept-00-sap-dw-0907.pdf>.

III. Appendices

E. Water Appendix

4. Effects of Drinking Water Treatment on Organophosphate Pesticides

The weight of evidence from open literature and studies conducted by a registrant, an ORD/EPA laboratory investigation, and the USGS-EPA drinking water reservoir monitoring program (Appendix III.E.3) show that parent organophosphorus (OP) insecticides in raw drinking water are removed or transformed during drinking water treatment. The most probable degradation pathway is chemical oxidation through chlorination, and in some cases, chemical water softening techniques may contribute to chemical degradation. In the USGS-EPA pilot reservoir monitoring program, oxidation degradation products of OP pesticides, such as sulfones, sulfoxides, and oxons, have been detected in finished water samples from actual water treatment plants. Additionally, the drinking water reservoir monitoring data suggest that malathion degradation during the water treatment process may have led to malaoxon formation in some finished water samples. Laboratory studies have shown that oxons, which may be relatively stable in chlorinated drinking water for periods of at least 24 - 48 hours, are formed in chlorinated water. These data suggest that oxidative degradation products such as oxons, sulfones, and sulfoxides have a likelihood of occurrence in finished drinking water when organophosphorus pesticides are present in raw water.

a. Introduction

This section provides a critical review of the available data that was used to assess water treatment effects on removal and transformation of organophosphorus pesticides and certain degradation products. This review was conducted as an extension of the OPP water treatment literature review presented to a Federal Insecticide, Fungicide, and Rodenticide Act Scientific Advisory Panel (FIFRA SAP) (<http://www.epa.gov/scipoly/2000/September/sept-00-sap-dw-0907.pdf>). Documents in this report included information on the chemistry of chlorination and softening in different water treatment processes and their effects on organophosphorus pesticide degradation, registrant-sponsored water treatment data, and ORD/EPA water treatment data. In addition, water treatment effects are discussed in the USGS-OPP pilot reservoir monitoring section.

The effects of water treatment were evaluated with primary focus on disinfection by chlorination and softening. Chlorine treatment is widely used in the United States, and has been associated with the transformation of certain organophosphorus pesticides to products with toxicity and health concerns. Softening was also considered because organophosphorus pesticides have the potential to hydrolyze under alkaline conditions.

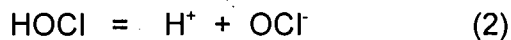
b. Drinking Water Disinfection

Disinfection of raw or untreated water for potable uses is a process that is used to eliminate disease-causing or pathogenic microorganisms. The pathogens are generally bacteria such as *Salmonella*, viruses such as *Poliovirus*, and protozoa such as *Cryptosporidium* and *Giardia*. These microorganisms can be destroyed by physical treatment (heat or boiling), ultraviolet (UV) radiation, or chemical treatment. UV radiation kills by photodegradation of nucleic acids in microorganisms while chemical treatment (chlorine or other oxidants) destroys pathogens by oxidizing the cell walls. Other chemicals such as ozone, potassium permanganate, copper and silver ions, quaternary ammonium compounds, strong acids and bases can also inactivate microorganisms. In this report, however, the emphasis will be on disinfection by treatment with chlorine and chlorine compounds.

i. Treatment by Chlorine and Chlorine Compounds

Currently in the United States, chlorine and its related compounds are commonly used for drinking water disinfection. By far, chlorine gas is the most widely used disinfectant in water treatment utilities and also can be used for oxidizing iron, manganese and hydrogen sulfide, and for controlling tastes, odors, algae, and slime. Other compounds, such as sodium hypochlorite (NaClO), chlorine dioxide (ClO₂), and chloramines may be used in place of chlorine gas in other community water systems.

Chlorine: (Cl₂) is a dense gas typically shipped in pressurized tanks to water treatment facilities. It dissolves in water and undergoes hydrolysis or disproportionation as shown in equation. (1):



The hydrolysis rate is so rapid that the reaction is complete in less than a second. The product HOCl (hypochlorous acid) also hydrolyzes in water to form OCl⁻ (hypochlorite) according to eq.(2), with an acid dissociation constant (pKa) of 7.5. The pKa value suggests that at pH of 7.5, 50% of HOCl exists as HOCl and 50% as OCl⁻. At pH conditions commonly encountered in finished or treated waters (~ pH 6 - 9), molecular Cl₂ is not practically important. At pH > 3 and with chlorine dosage of 100 mg/L, very little or negligible Cl₂ is present. Consequently, the dependence of HOCl dissociation on pH and distribution between of HOCl and OCl⁻ are needed in order to understand the efficiency of disinfection by chlorine treatment along with the chlorine effects on pesticides and other organic compounds. HOCl and OCl⁻ have considerably different capabilities of inactivating and destroying microorganisms. HOCl has a greater bactericidal

efficiency than OCl^- . The protonated species HOCl has been reported to be more reactive and has a higher oxidation efficiency than the unprotonated species OCl^- . Thus, it is important to measure pH as a water quality parameter in water disinfection studies.

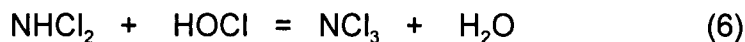
Hypochlorite: Sodium hypochlorite (NaClO) and occasionally calcium hypochlorite [$\text{Ca}(\text{ClO})_2$] are used instead of chlorine gas for water disinfection. Both salts dissolve to form the hypochlorite ion which eventually hydrolyzes in water according to eq. (3):



With the formation of a strong base (OH^-), the alkalinity of the water can be affected. One mole of NaClO or 0.5 mole of $\text{Ca}(\text{ClO})_2$ will result in an increase of one equivalent of alkalinity. This becomes significant during superchlorination with hypochlorite in which a higher dose is used to achieve disinfection as well as remove iron and manganese and simultaneously control taste and odor.

Chlorine Dioxide: ClO_2 , like chlorine, is a dense gas with chlorinous odor. However, unlike chlorine, it remains in a molecular form as ClO_2 in water and does not undergo hydrolysis. Once dissolved in water, it can be transformed under alkaline conditions to chlorite (ClO_2^-) and chlorate (ClO_3^-), both of which are undesirable in drinking water. It does not react with ammonia and does not form trihalomethanes, haloacetic acids, and other halogenated disinfection by-products typically associated with chlorine treatment. Disinfection/oxidation products identified from ClO_2 treatment include aldehydes and carboxylic acids, with low levels of some chlorinated compounds.

Chloramines: Dissolved ammonia present or intentionally added to water can react with hypochlorous acid or hypochlorite to form chloramines. The stepwise reactions can be represented as follows:



The products from reactions (4), (5), and (6) are respectively monochloramine, dichloramine, and trichloramine or nitrogen trichloride. These chloramines have relatively lower biocidal and oxidation efficiency. Collectively, the three chloramine species contribute to the combined chlorine residual. The relative amount of each chloramine depends on pH and molar or dose ratio of $\text{Cl}:\text{N}$. The free chlorine residual is associated with the concentration of HOCl or

OCl^{-1} or both. The total chlorine residual is taken as the sum of the free and combined chlorine residuals which can be analytically determined using procedures in Standard Methods of Analysis.

ii. Reactions of Chlorine with Organic Compounds and Pesticides

Chlorine gas and other chlorine compounds can react with chemicals dissolved in water to form different disinfection products. In the water treatment facilities, the reactions can be generally categorized as oxidation, substitution/addition, and dechlorination.

Oxidation: All the disinfectants used in the United States have the capacity to oxidize certain chemicals in raw or untreated water with varying efficiencies. These chemicals are reduced metal ions, aldehydes, ketones, alcohols, and other organic compounds that include pesticides. Aldehydes and ketones can be converted to carboxylic acids. Thiocarbamates can be transformed to sulfoxides, and eventually to sulfones. The $\text{P}=\text{S}$ bond of organophosphate pesticides (OPs) can be oxidized to $\text{P}=\text{O}$ bond, leading to the formation of oxon. Based on the available data, several OPs are transformed to their corresponding oxons (Magara et al (1994); Tierney, et al., 2000). For instance, diazinon is oxidized to diazoxon which is relatively stable in chlorinated water for about 48 hours.

Substitution/Addition Reactions: HOCl or OCl^{-1} can also react with organic compounds by displacing chemical species and incorporating chlorine atoms. This reaction is responsible for the formation of trihalomethanes and haloacetic acids that are currently regulated under the Disinfection By-Products rule (DBP). Other by-products include chlorinated phenols, aromatic hydrocarbons, and alkenes. Pesticides may also undergo substitution/addition reaction with chlorine to form chlorinated products. Magara et al (1994) presented chlorine treatment effects data that show the transformation of thiobencarb to chlorobenzyl chloride, chlorobenzyl alcohol, chlorobenzyl aldehyde, and chlorobenzoic acid. Some of these treatment transformation products have been detected in a Japanese water purification facility.

Dechlorination: Occasionally, the level of chlorine residual may be high at the end of the treatment train. Thus, it is necessary to reduce the chlorine residual before the finished water is transported through the distribution system. This can be accomplished by dosing with compounds that can react with chlorine or increase the rate of decomposition of chlorine residual.

Compounds typically used for dechlorination include sulfur dioxide and reduced sulfur compounds such as sodium sulfite, bisulfite, and

thiosulfate. In some instances, activated carbon can be used for dechlorination. Reactions of sulfur compounds such as sulfur dioxide generate acidic products (hydrochloric and sulfuric acids) that can decrease the alkalinity of the finished water.

c. Water Softening

Raw waters which are hard or those with high levels of calcium and magnesium are typically treated to reduce the concentrations of these two metal cations. This process, known as softening, can be achieved by the use of ion-exchange resins or precipitating agents. When lime and soda ash are added to water, the pH and carbonate alkalinity are increased which favor the precipitation of calcium as calcium carbonate and magnesium as magnesium hydroxide. Under this condition, the pH can increase to about 10 - 11, leading to base-catalyzed hydrolysis of pesticides such as organophosphate insecticides. OPs are generally hydrolyzed in the environment by nucleophilic substitution reactions. At pH 7 at 20° C, the hydrolysis half-lives of certain OPs (Larson and Weber, 1994) are follows:

Phosmet ----- 7.1 hours
 Malathion ----- 10.5 days
 Chlorpyrifos ----- 78 days
 Parathion ----- 130 days

At softening pH of 10 -11 likely to be encountered in water treatment plants, hydrolysis rates would be expected to proceed much faster especially for phosmet and malathion.

d. EPA/ORD Studies on OP Pesticide Removal and Transformation by Water Treatment

EPA/ORD's AWBERC laboratory in Cincinnati, OH, conducted a laboratory study to determine the effects of chlorination and softening on certain pesticides [U.S. EPA. 2001. Laboratory Study on Chlorination and Softening Effects on Pesticide Residues in Drinking Water. Work Assignment (1-22) between EFED and ORD.] Chlorpyrifos-methyl was one of the pesticides used in the chlorination experiment. Malathion and phorate were used in the softening experiment.

i. Chlorination Jar Test

Well water was taken from a treatment plant in Ohio and then subsequently used in the jar experiments for evaluating the effects of chlorination of several pesticides, including chlorpyrifos-methyl. The test water was spiked with about 20 - 100 ug/L of pesticides from the prepared stock solutions. The chlorination was performed under Uniform Formation Conditions (UFC): pH 8.0 ± 0.2 ; temperature of $20.0 \pm .0^{\circ}\text{C}$; dark

incubation time of 24 ± 1 hr.; chlorine residual of 1.0 ± 0.4 mg/L as free chlorine after 24 hr. The samples were dosed with hypochlorite-buffer solution. After the test, the samples were quenched with sodium sulfite prior to analysis. Chlorpyrifos-methyl, along with the other pesticides, was analyzed according to Method 525.2 (GC/MS), which has a method detection limit (MDL) of 0.025 for chlorpyrifos-methyl.

ii. Softening Jar Test

Well water used in the chlorination test was also used in the water softening experiment. The raw water was spiked with < 20 to 300 ug/L of pesticides that include 2 OPs, malathion and phorate. Hardness was reduced by treating the raw water with 50 and 300 mg/L of lime which corresponded to conventional magnesium softening conditions at about 20°C. Water was exposed to lime for 3 hr. before water samples were analyzed using Method 525.2 (GC/MS). The MDLs for malathion and phorate were 0.015 and 0.050 ug/L, respectively. The softening experiment was conducted with 3 replicates for each pesticide.

iii. Summary of Results

The well water used in both tests was analyzed for basic water quality parameters and the results are summarized in Table III.E.4.1. The water was slightly alkaline and had high hardness.

Table III.E.4.1. Raw Water Quality Characteristics Used in the USEPA ORD Laboratory Studies

Parameter	Sample I	Sample II
Hardness (mg/L as CaCO ₃)	315	293
pH	7.44	7.78
Temperature (C°)	23.6	23.6
Alkalinity (mg/L as CaCO ₃)	220	230
Turbidity (NTU*)	2.7	1.4
TOC** (mg/L)	1.39	1.36

*NTU=Nephelometric Turbidity Unit

**TOC=Total Organic Carbon

Table III.E.4.2 shows the results of the chlorination and softening jar tests for the 3 OP's. The concentrations represent the mean value of four replicates for chlorination studies and three replicates for softening studies. About 90% of chlorpyrifos-methyl was removed by chlorine treatment. The reduction in pesticide concentration is most probably due to oxidation of the insecticide to oxons and other products. During softening, relatively higher removal efficiencies were observed in the 300 mg/L treatment than

those in the 150 mg/L treatment. More than 99 % of malathion was removed, while phorate removal was lower (20%). It is believed that alkaline hydrolysis was responsible for the significant concentration reduction of malathion.

Table III.E.4.1. Effects of Chlorination and Softening on OP Pesticides in the USEPA ORD Laboratory Studies

Chlorination	Mean Concentration (ug/L)			% Removal
	Control		Treated	
	t=0	t=24		
Chlorpyrifos-methyl	45	43	<5	> 89*

Softening	Mean Concentration (µg / L)				% Removal	
	Control		150 mg/L	300 mg/L	150 mg/L	300 mg/L
	t=0	t=24				
Malathion	320	320	75	<2	73*	>99*
Phorate	74	75	73	62	2	17*

*Significantly lower than controls at 95%

e. Registrant Sponsored Water Treatment Data

Syngenta Crop Protection submitted a study to OPP in 2001 that evaluated the effect of chlorination on six OP pesticides and four of their oxon transformation products [Tierney, D.P., B.R. Christensen, and V.C. Culpepper. 2001. Chlorine Degradation of Six Organophosphorus Insecticides and Four Oxons in Drinking Water Matrix. Submitted by Syngenta Crop Protection, Inc. Greensboro, NC. Performed by Syngenta Crop Protection, En-fate, LLC., and EASI Laboratory.]. The results of the study are difficult to interpret because the study does not contain water quality data, appropriate treatment controls, and a complete description of sample storage data.

The data indicate that the six OP pesticides (acephate, azinphos-methyl, chlorpyrifos, diazinon, malathion, and methamidophos) are transformed in chlorinated drinking water. Chemical oxidation of the organophosphorus compounds led to the formation of oxons for azinphos-methyl, chlorpyrifos, diazinon, and malathion. The oxons were more stable than their parent organophosphorus pesticides, and degradation of oxons was attributed to non-chlorine degradation processes and/or hydrolysis. Chloramines were formed during the experiment. Because chloramines have a lower oxidizing potential than hypochlorous acid, the extent of degradation and formation of

oxidative degradation products (oxons) may be different under conditions of equivalent or higher free chlorine concentrations.

i. Study Design

The study was designed to assess the impact of total residual chlorine on the degradation of six organophosphorus pesticides (acephate, azinphos-methyl, chlorpyrifos, diazinon, malathion, and methamidophos) and certain transformation products (azinphos-methyl oxon, chlorpyrifos oxon, diazinon oxon, and malathion oxon).

Study 1: OP Pesticides and Oxon Transformation Products (azinphos-methyl, chlorpyrifos, diazinon, malathion, azinphos-methyl oxon, chlorpyrifos oxon, diazinon oxon, and malathion oxon)

Twenty liter samples of dechlorinated treated drinking water (total residual chlorine concentration=0.02 mg/L as Cl_2) from the Jefferson Parish Louisiana Water Treatment Plant were treated with sodium hypochlorite to yield total residual chlorine (Cl_2) concentrations of 1.9 mg/L and 4.1 mg/L. The free chlorine concentration for the 1.9 mg/L and 4.1 mg/L chlorine treatments was < LOD and ~2 mg/L, respectively. Each bulk water sample was fortified with a working standard mixture of organophosphorus pesticides or organophosphorus degradation products to yield pesticide concentrations of 0.500 ug/L (500 ng/L).

Treatment controls were prepared using a 10 liter sample of finished drinking water from the Jefferson Parish Louisiana Water Treatment Plant. The water sample was amended with sodium hypochlorite to yield a total chlorine residual of 2 mg/L. The total chlorine in the water sample was removed by quenching with 300 mg/L of sodium thiosulfate. A chlorine analysis of the water sample confirmed removal of residual chlorine.

Pesticide fortified water and treatment controls were partitioned into separate 1 liter borosilicate glass jars. Three replicates were used for each of 5 sampling times (0, 15 minutes, 30 minutes, 60 minutes, and 24 hours) and 3 chlorine concentrations (treatment control (no chlorine), 2.0 mg/L, and 4 mg/L). Treatment controls had 3 replicate for the 0 and 24 hours sampling interval. At each sampling time, the chlorine residual in each 1 liter sample was removed through quenching with ~300 mg of sodium thiosulfate. Residual chlorine removal was verified in a single sample fortified with 4.0 mg/L chlorine.

At each sampling time, replicates samples were refrigerated at 4°C prior to extraction. Samples were extracted using C-18 solid phase extraction disks and analyzed using gas chromatography /mass

spectrometry. The limit of detection (LOD) and limit of quantitation (LOQ) were 0.01 ug/L and 0.05 ug/L, respectively. The registrant stated that all concentrations less than the LOQ were considered as non-detections. Quality assurance and control measures were implemented. Each analysis group of 20 samples consisted of experimental samples, method blank, matrix blank, matrix spike at 0.500 ug/L and duplicate matrix spike.

Diazinon, chlorpyrifos, and azinphos methyl were stable in nonchlorinated control water, while malathion, diazinon oxon, chlorpyrifos oxon, malathion oxon, and azinphos methyl oxon had degraded significantly ($p=0.05$) degradation in the control water. After 24 hours, the percent remaining was 97% for diazinon, 96% for chlorpyrifos, 76% for malathion, 90% for azinphos-methyl, 90% for diazinon oxon, 85% for chlorpyrifos oxon, 55% for malathion oxon, and 62% for azinphos methyl oxon. The registrant stated that observed degradation may be due to non-chlorine degradation processes and/or hydrolysis. The pre-treated test water was 7.24.

There was partial degradation of parent organophosphorus insecticides in the 2 mg/L of total chlorine treatment. After 24 hours, the percent parent remaining was 47% for diazinon, 53% for chlorpyrifos, 53% for malathion, and 51% for azinphos methyl.

Degradation of parent to oxons was observed and expressed as percent of parent concentration as follows: 1) 30% for diazinon oxon, 2) 20% for chlorpyrifos oxon, 3) 15% for malathion oxon, and 4) 10% for azinphos methyl oxon. Oxon degradation (21 to 40% of the peak concentration) was observed in the 2 mg/L total chlorine treatment after 24 hours.

Complete degradation of parent organophosphorus compounds occurred in the 4 mg/L total chlorine treatment where degradation was complete within 30 minutes. Oxidative degradation of parent compounds led to the formation of oxons with peak oxon concentrations were 60% for diazinon, 74% for chlorpyrifos, 64% for malathion, and 31% for azinphos methyl. Oxon degradation appeared to be partially dependent on oxidation from chlorine. Diazinon oxon and chlorpyrifos oxon had significant degradation in the 4 mg/L chlorination treatment. Malathion oxon and azinphos methyl degradation was not significantly different than the treatment control.

Study 2: Acephate and Methamidophos

Chlorine degradation studies for acephate and methamidophos were conducted using similar procedures as described above. The experimental design were similar to the previously described study

(Study 1). Modification in the experimental design are associated with the pesticide fortification process and analytical methods. Because acephate degrades to form methamidophos, chlorine degradation studies were conducted for the individual compounds rather than a mixture of the two. The pesticide fortification method was different because an acetone co-solvent was used in the working standard solution. The acetone co-solvent was allowed to evaporate prior to reconstitution in deionized water. The reconstituted solution was used to fortify bulk water samples.

At each sampling time, the replicate samples were refrigerated at 4°C prior to extraction. Samples were extracted using AC-2 graphitized solid phase extraction tubes and analyzed using gas chromatography/flame photometric detection. The LOD and LOQ were 0.01 ug/L and 0.05 ug/L, respectively. The registrant stated all concentrations less than the LOQ were considered as non-detections.

Methamidophos and acephate degraded in control water by 14% and 7%, respectively, during a 24 hour incubation period. In the 2 mg/L chlorine treatment, both compounds degraded by ~40% during a 24 incubation period. Acephate and methamidophos were completely degraded within 15 minutes and 24 hours, respectively. Methamidophos was not identified as an oxidative degradation product of acephate.

ii. Uncertainties in Study

Water quality data, which are essential for understanding the water chemistry, were not provided in the report. Important water quality parameters include pH, hardness, alkalinity, total organic carbon content, and concentrations of free chlorine, residual chlorine, NH_4^+ , Na^+ , Ca^{+2} , Mg^{+2} , SO_4^{-2} , Cl^- , NO_2^- , Br^- and F^- . The Agency needs these data to confirm the registrant's claim that ammonium concentrations in tap water led to the formation of chloramines. The only available water quality data for test waters was pH (7.24). The registrant also submitted partial water quality data which was unitless for alkalinity, hardness, total solids, and fluoride for raw and treated water at the Jefferson Parish water treatment plant. The lack of units prevents use of the water quality data.

There are no data or adequate treatment control to assess the impact of sodium thiosulfate on water chemistry. The treatment control water was treated with 2 mg/L chlorine and then quenched with 300 mg/L sodium thiosulfate. The study did not include a similar sodium thiosulfate treatment regime was in the chlorine treatments and a control water sample without sodium thiosulfate. The Agency recommends that treatment control water be treated in the same manner as the water used in chlorine treatments. The addition of sodium thiosulfate in the treatment

control confounds interpretation of the data when compared to the chlorine treatments. Additionally, the lack of treatment control (without sodium thiosulfate) limits the ability to assess the impact of sodium thiosulfate on water chemistry.

Storage stability data used to compute average recovery were incomplete. The registrant claim that average percent recoveries ranged from 80 to 165% for extract storage times greater than 40 days. The registrant submitted additional data on matrix spike recoveries to substantiate the stability of analytes in extracts. Sample extracts were stored for two months prior to chemical analysis. Registrant calculated average matrix spike recoveries ranged from 59 to 83% for the C-18 method and 52 to 108% for the GC/PFD method. The relative percent difference (RPD) for duplicate matrix spikes ranged from 1 to 12% for the C-18 method and 8% to 48% for the GC/PFD method. Based on performance standards, matrix spike recoveries for the C-18 and GC/PFD methods should range from 70 to 120%. These data indicated that analytical recoveries in matrix spikes for most analytes (exceptions chlorpyrifos oxon and methamidophos) could be explained by analytical method performance. Low mean recoveries for chlorpyrifos oxon and methamidophos, however, could not be explained by the method performance alone. The Agency believes the low recoveries of chlorpyrifos oxon and methamidophos suggest that degradation or some other factor contributed to low recoveries in matrix spike samples.

III. Appendices

E. Water Appendix

5. Chemical-Specific Inputs Used in the Drinking Water Exposure Assessment

Table III.E.5-1 PRZM/EXAMS Input Values for Acephate

Property/ Parameter	PRZM Variable Name	Value	Units	Comments / References
Molecular weight	mwt	183.16	g/mol	RED
Henry's Law Const.	henry	5.10E-13	atm-m ³ /mol	Calculated
Vapor Pressure	vapr	1.70E-06	torr	MRID 40390601, cited in RED. At 24°C (Technical)
Solubility	sol	8.01E+05	mg/L	MRID 40390601, cited in RED. Technical at 25°C
Kd	Kd	0.09	mg/L	MRID 40504811. Only value available: adsorbed in only one of the five soils (clay loam) used in the batch equilibrium studies.
Koc	Koc	4.7	mg/L	MRID 40504811. Only value available: adsorbed in only one of the five soils (clay loam) used in the batch equilibrium studies.
Photolysis half-life	kdp	0	days	MRID 41081603; stable at pH 7
Aerobic Aquatic Metabolism	kbacw	4.6	days	No data available; used 2x 162-1 (MRID 00014991)
Anaerobic Aquatic Metabolism	kbacs	19.8	days	MRID 43971601; 3x single value of 6.6 days
Aerobic Soil Metabolism	asm	2.3	days	MRID 00014991; 90% CI on mean using three values.
Hydrolysis:	pH 5	0	days	MRID 41081604; stable
Hydrolysis:	pH 7	0	days	MRID 41081604; stable
Hydrolysis:	pH 9	18	days	MRID 41081604
Method:	CAM	2	integer	Foliar broadcast modeled in RED; also includes in-furrow treatments
Incorporation Depth:	DEPI	0	cm	Foliar broadcast or pre-plant @ 2-4 in incorporation
Record 17:	FILTRA			
	IPSCND			
	UPTKF			
Record 18:	PLVKRT			
	PLDKRT			
	FEXTRC			

Table III.E.5.2. PRZM/EXAMS Input Values for Azinphos Methyl

Property/ Parameter	PRZM Variable Name	Value	Units	Comments / References
Molecular weight	mwt	317.32	g/mol	EFED One-Liner
Henry's Law Const.	henry		atm-m ³ /mol	MRID
Vapor Pressure	vapr	2.20E-07	torr	EFED One-Liner
Solubility	sol	25.1	mg/L	EFED One-Liner
Kd	Kd	7.6	mg/L	MRID 42959702
Koc	Koc		mg/L	
Photolysis half-life	kdp	3.19	days	MRID 40297001
Aerobic Aquatic Metabolism	kbacw	191.6	days	2X aerobic soil input parameter
Anaerobic Aquatic Metabolism	kbacs	396	days	MRID 29900/ 2x anaerobic soil input parameter
Aerobic Soil Metabolism	asm	95.8	days	MRID 29900/ 3x single value
Hydrolysis:	pH 5	38	days	MRID 40297001
Hydrolysis:	pH 7	37	days	MRID 40297001
Hydrolysis:	pH 9	6.9	days	MRID 40297001
Method:	CAM	2	integer	
Incorporation Depth:	DEPI	0	cm	
Record 17:	FILTRA			
	IPSCND			
	UPTKF			
Record 18:	PLVKRT			
	PLDKRT	9.9	days	see EFED RED Chapter
	FEXTRC	0.937	cm ⁻¹	see EFED RED Chapter

Table III.E.5.3. PRZM/EXAMS Input Values for Bensulide

Property/ Parameter	PRZM Variable Name	Value	Units	Comments / References
Molecular weight	mwt	397.5	g/mol	RED
Henry's Law Const.	henry	7.80E-08	atm-m ³ /mol	RED; calculated value
Vapor Pressure	vapr	8.20E-07	torr	MRID 41532001
Solubility	sol	5.6	mg/L	MRID 41532001
Kd	Kd	43.1	mg/L	MRID 42826701; average of 4 (11, 30.5, 96.8, 34) values
Koc	Koc	2943	mg/L	MRID 42826701; average of 4 values
Photolysis half-life	kdp	200	days	MRID 40513401: Stable
Aerobic Aquatic Metabolism	kbacw	726	days	No study; value is 2x aerobic soil metabolism input value
Anaerobic Aquatic Metabolism	kbacs	0	days	No study; stable in anaerobic soil metabolism study (MRID 40460302)
Aerobic Soil Metabolism	asm	363	days	MRID 40460301; single value (not x3 because of large value)
Hydrolysis:	pH 5	230	days	MRID 00160074
Hydrolysis:	pH 7	220	days	MRID 00160074
Hydrolysis:	pH 9	220	days	MRID 00160074
Method:	CAM	1	integer	Veg: unincorporated ground
Incorporation Depth:	DEPI	0	cm	Unincorporated or incorporated to 4-cm depth
Record 17:	FILTRA			
	IPSCND			
	UPTKF			
Record 18:	PLVKRT			
	PLDKRT			
	FEXTRC			

Table III.E.5.4. PRZM/EXAMS Input Values for Chlorethoxyfos

Property/ Parameter	PRZM Variable Name	Value	Units	Comments / References
Molecular weight	mwt	336	g/mol	MRID
Henry's Law Const.	henry	8.00E-03	atm-m ³ /mol	MRID
Vapor Pressure	vapr	1.70E-03	torr	MRID
Solubility	sol	2.1	mg/L	MRID
Kd	Kd	111	mg/L	MRID 41290618; mean of 40, 53, 150, 200
Koc	Koc		mg/L	
Photolysis half-life	kdp	27	days	MRID 41736821
Aerobic Aquatic Metabolism	kbacw	46	days	No study available; 2x aerobic soil metabolism half-life value
Anaerobic Aquatic Metabolism	kbacs	94	days	No study avail; 2x anaer soil met t1/2 of 47 da; MRID 41736825
Aerobic Soil Metabolism	asm	23	days	Range 20-23 da; MRIDs 40883706, 41736824
Hydrolysis:	pH 5	72	days	MRID 40883705
Hydrolysis:	pH 7	59	days	MRID 40883705
Hydrolysis:	pH 9	4.3	days	MRID 40883705
Method:	CAM	7	integer	In-furrow, t-band (11/23/98 DW assessment, Matzner)
Incorporation Depth:	DEPI	2	cm	11/23/98 DW assessment, Matzner
Record 17:	FILTRA			
	IPSCND			
	UPTKF			
Record 18:	PLVKRT			
	PLDKRT			
	FEXTRC			

Table III.E.5.5. PRZM/EXAMS Input Values for Chlorpyrifos

Property/ Parameter	PRZM Variable Name	Value	Units	Comments / References
Molecular weight	mwt	351	g/mol	RED
Henry's Law Const.	henry	4.20E-06	atm-m ³ /mol	RED
Vapor Pressure	vapr	1.87E-05	torr	RED
Solubility	sol	2	mg/L	RED
Kd	Kd		mg/L	
Koc	Koc	6070	mg/L	MRIDs 00155636, 00155637, 40050401, 41892801, 41892802, 42493901; mean of range 360-31000
Photolysis half-life	kdp	30	days	MRID 41747206
Aerobic Aquatic Metabolism	kbacw	154	days	No study avail; 2x aerobic soil metabolism input
Anaerobic Aquatic Metabolism	kbacs	126.7	days	No study avail; 2x anaerobic soil met (15-58 da), MRID 00025619
Aerobic Soil Metabolism	asm	77	days	90%th pct CI on mean of range 11-180 da; MRIDs 00025619, 42144911, 42144912
Hydrolysis:	pH 5	72	days	MRID 00155577
Hydrolysis:	pH 7	72	days	MRID 00155577
Hydrolysis:	pH 9	16	days	MRID 00155577
Method:	CAM		integer	Includes both aerial/foliar and ground/broadcast/incorporated
Incorporation Depth:	DEPI		cm	
Record 17:	FILTRA			
	IPSCND			
	UPTKF			
Record 18:	PLVKRT			
	PLDKRT			
	FEXTRC			

Table III.E.5.6. PRZM/EXAMS Input Values for Diazinon

Property/ Parameter	PRZM Variable Name	Value	Units	Comments / References
Molecular weight	mwt	304.34	g/mol	RED
Henry's Law Const.	henry	1.40E-06	atm-m ³ /mol	RED
Vapor Pressure	vapr	1.40E-04	torr	RED
Solubility	sol	40	mg/L	RED
Kd	Kd		mg/L	
Koc	Koc	758	mg/L	MRID 40512601; see Jones, 2000; D271987
Photolysis half-life	kdp	52	days	MRID 00153229; see Jones, 2000; D271987
Aerobic Aquatic Metabolism	kbacw	82	days	RED Chapter for Diazinon; 2x aerobic soil metabolism value
Anaerobic Aquatic Metabolism	kbacs	164	days	2x aerobic aquatic metabolism value
Aerobic Soil Metabolism	asm	41	days	EFED RED Chapter for Diazinon; 90% CI on mean
Hydrolysis:	pH 5	12	days	EFED RED Chapter for Diazinon
Hydrolysis:	pH 7	138	days	EFED RED Chapter for Diazinon
Hydrolysis:	pH 9	77	days	EFED RED Chapter for Diazinon
Method:	CAM	2	integer	
Incorporation Depth:	DEPI	0	cm	
Record 17:	FILTRA			
	IPSCND			
	UPTKF			
Record 18:	PLVKRT			
	PLDKRT			
	FEXTRC			

Table III.E.5.7. PRZM/EXAMS Input Values for Dichlorvos (DDVP)

Property/ Parameter	PRZM Variable Name	Value	Units	Comments / References
Molecular weight	mwt	221	g/mol	From RED
Henry's Law Const.	henry	5.01E-08	atm-m ³ /mol	Measured (from RED)
Vapor Pressure	vapr	1.21E-02	torr	
Solubility	sol	15000	mg/L	From RED
Kd	Kd		mg/L	
Koc	Koc	37	mg/L	41723103, 40034904
Photolysis half-life	kdp	0	days	43326601--stable with longer irradiated half-lives than dark control
Aerobic Aquatic Metabolism	kbacw	2.5	days	no data; 2x aerobic soil metabolism half-life value
Anaerobic Aquatic Metabolism	kbacs	12.6	days	no data; 2x anaerobic soil metabolism half-life value (43835701)
Aerobic Soil Metabolism	asm	1.25	days	41723102; 3x single half-life value
Hydrolysis:	pH 5	12	days	41723101
Hydrolysis:	pH 7	5	days	41723101
Hydrolysis:	pH 9	0.875	days	41723101
Method:	CAM		integer	
Incorporation Depth:	DEPI		cm	
Record 17:	FILTRA			
	IPSCND			
	UPTKF			
Record 18:	PLVKRT			
	PLDKRT			
	FEXTRC			

Table III.E.5.8. PRZM/EXAMS Input Values for Dicrotophos

Property/ Parameter	PRZM Variable Name	Value	Units	Comments / References
Molecular weight	mwt	237.19	g/mol	MRID 43772301
Henry's Law Const.	henry	3.13E-11	atm-m ³ /mol	RED; calculated
Vapor Pressure	vapr	7.00E-05	torr	MRID 43500401
Solubility	sol	11990	mg/L	MRID 43603202, 43603201
Kd	Kd		mg/L	
Koc	Koc	73	mg/L	MRID 00160828; mean of 11, 40, 53, 187
Photolysis half-life	kdp	0	days	stable; 160824
Aerobic Aquatic Metabolism	kbacw	18	days	No data; aer soil met input value x 2
Anaerobic Aquatic Metabolism	kbacs	0	days	no data
Aerobic Soil Metabolism	asm	9	days	160826, single value (3 days) x 3
Hydrolysis:	pH 5	117	days	160823
Hydrolysis:	pH 7	72	days	160823
Hydrolysis:	pH 9	28	days	160823
Method:	CAM		integer	
Incorporation Depth:	DEPI		cm	
Record 17:	FILTRA			
	IPSCND			
	UPTKF			
Record 18:	PLVKRT			
	PLDKRT			
	FEXTRC			

Table III.E.5.9. PRZM/EXAMS Input Values for Dimethoate

Property/ Parameter	PRZM Variable Name	Value	Units	Comments / References
Molecular weight	mwt	229.2	g/mol	RED
Henry's Law Const.	henry	8.00E-11	atm-m ³ /mol	RED
Vapor Pressure	vapr	1.85E-06	torr	RED
Solubility	sol	4.00E+04	mg/L	RED
Kd	Kd	0.42	mg/L	MRID 00164959; average of 4 (0.06, 0.30, 0.57, 0.74) values
Koc	Koc		mg/L	
Photolysis half-life	kdp	0	days	MRID 00159762: Stable
Aerobic Aquatic Metabolism	kbacw	14.4	days	No study; value is 2x aerobic soil metabolism input value
Anaerobic Aquatic Metabolism	kbacs	44	days	No study; value is 2x anaerobic soil metabolism input value (MRID 42843201)
Aerobic Soil Metabolism	asm	7.2	days	MRID 42843201; 3x single half-life value
Hydrolysis:	pH 5	156	days	MRID 00159761
Hydrolysis:	pH 7	68	days	MRID 00159761
Hydrolysis:	pH 9	4.4	days	MRID 00159761
Method:	CAM	2	integer	Typically foliar application
Incorporation Depth:	DEPI	0	cm	
Record 17:	FILTRA			
	IPSCND			
	UPTKF			
Record 18:	PLVKRT			
	PLDKRT			
	FEXTRC			

Table III.E.5.10. PRZM/EXAMS Input Values for Disulfoton Total Toxic Residues

Property/ Parameter	PRZM Variable Name	Value	Units	Comments / References
Molecular weight	mwt	274.39	g/mol	Parent; MRID 150088
Henry's Law Const.	henry	2.60E-06	atm-m ³ /mol	Parent; RED
Vapor Pressure	vapr	1.8X10 ⁻⁴	torr	Parent; RED
Solubility	sol	15	mg/L	Parent; MRID 150088
Kd	Kd		mg/L	
Koc	Koc	552	mg/L	Parent; MRID 44373103; no data for sulfoxide & sulfone, which are expected to be more mobile than parent
Photolysis half-life	kdp	4	days	Parent; MRID 40471102; 93 hr half-life
Aerobic Aquatic Metabolism	kbacw	260	days	Set to = aerobic soil
Anaerobic Aquatic Metabolism	kbacs		days	No valid study available
Aerobic Soil Metabolism	asm	260	days	MRIDs 43800101, 40042201, 41585101; Sulfoxide = 17 days; sulfone = 150 days; upper CI on mean
Hydrolysis:	pH 5	1174	days	parent; MRID 00143405
Hydrolysis:	pH 7	323	days	parent; MRID 00143405
Hydrolysis:	pH 9	231	days	parent; MRID 00143405
Method:	CAM		integer	
Incorporation Depth:	DEPI		cm	
Record 17:	FILTRA			
	IPSCND			
	UPTKF			
Record 18:	PLVKRT			
	PLDKRT			Foliar diss rate 3.3 da; MRID 41201801
	FEXTRC			

Table III.E.5.11. PRZM/EXAMS Input Values for Disulfoton Parent Compound Only

Property/ Parameter	PRZM Variable Name	Value	Units	Comments / References
Molecular weight	mwt	274.39	g/mol	MRID 150088
Henry's Law Const.	henry	2.60E-06	atm-m ³ /mol	RED (measured)
Vapor Pressure	vapr	1.8X10-4	torr	RED; 20C
Solubility	sol	15	mg/L	MRID 150088, 20 C
Kd	Kd		mg/L	
Koc	Koc	552	mg/L	MRIDs 44373103, 00145469; mean of 386, 449, 483, 888
Photolysis half-life	kdp	4	days	MRID 40471102; 93 hr half-life
Aerobic Aquatic Metabolism	kbacw	12	days	No study available; 2x aerobic soil metabolism input value
Anaerobic Aquatic Metabolism	kbacs		days	No valid study available
Aerobic Soil Metabolism	asm	6	days	MRIDs 43800101, 40042201, 41585101; 90% CI on mean of 2 values
Hydrolysis:	pH 5	1174	days	MRID 00143405
Hydrolysis:	pH 7	323	days	MRID 00143405
Hydrolysis:	pH 9	231	days	MRID 00143405
Method:	CAM		integer	
Incorporation Depth:	DEPI		cm	
Record 17:	FILTRA			
	IPSCND			
	UPTKF			
Record 18:	PLVKRT			
	PLDKRT			Foliar diss rate 3.3 da; MRID 41201801
	FEXTRC			

Table III.E.5.12. PRZM/EXAMS Input Values for Ethoprop .

Property/ Parameter	PRZM Variable Name	Value	Units	Comments / References
Molecular weight	mwt	242.3	g/mol	RED
Henry's Law Const.	henry	1.49E-07	atm-m ³ /mol	RED
Vapor Pressure	vapr	3.50E-04	torr	RED
Solubility	sol	843	mg/L	RED
Kd	Kd	2.1	mg/L	MRID not given in RED; average of 4 (1.08, 1.24, 2.10, 3.78) values
Koc	Koc		mg/L	MRID
Photolysis half-life	kdp	0	days	MRIDs 41270702, 43833502; stable
Aerobic Aquatic Metabolism	kbacw	600	days	No study; value is 2x aerobic soil metabolism input value
Anaerobic Aquatic Metabolism	kbacs	300	days	MRID 00160171; 3x single half-life value
Aerobic Soil Metabolism	asm	300	days	MRID 00160171; 3x single half-life value
Hydrolysis:	pH 5	0	days	MRID 41270703; stable
Hydrolysis:	pH 7	0	days	MRID 41270703; stable
Hydrolysis:	pH 9	0	days	MRID 41270703; stable
Method:	CAM		integer	Incl. band incorporation, soil broadcast, broadcast incorp, in-furrow
Incorporation Depth:	DEPI		cm	Incorporated or watered in
Record 17:	FILTRA			
	IPSCND			
	UPTKF			
Record 18:	PLVKRT			
	PLDKRT			
	FEXTRC			

Table III.E.5.13. PRZM/EXAMS Input Values for Fenamiphos Total Toxic Residues

Property/ Parameter	PRZM Variable Name	Value	Units	Comments / References
Molecular weight	mwt	303.36	g/mol	EFED RED chapter; parent
Henry's Law Const.	henry		atm-m ³ /mol	
Vapor Pressure	vapr	9.97E-10	torr	EFED RED chapter; parent
Solubility	sol	400	mg/L	EFED RED chapter; parent
Kd	Kd	0.958	mg/L	MRID 407748-08; lowest non-sand Kf for parent; sulfoxide, sulfone more mobile in column leaching
Koc	Koc		mg/L	
Photolysis half-life	kdp	75	days	MRID 40608001; parent, corrected for dark control
Aerobic Aquatic Metabolism	kbacw	336	days	MRID 421493-03; 2x aerobic soil input parameter
Anaerobic Aquatic Metabolism	kbacs	399	days	MRID 412869-01; 6x anaerobic soil metabolism rate
Aerobic Soil Metabolism	asm	168	days	MRID 421493-03; half-life 62 d for sulfoxide, 29 d for sulfone; comb residue 56 days (x3)
Hydrolysis:	pH 5	247	days	MRID 421493-02; see Jones, RD, 2001, Revised Fenamiphos Est. Env. Conc.
Hydrolysis:	pH 7	300	days	MRID 421493-02; see Jones, RD, 2001, Revised Fenamiphos Est. Env. Conc.
Hydrolysis:	pH 9	231	days	MRID 421493-02; see Jones, RD, 2001, Revised Fenamiphos Est. Env. Conc.
Method:	CAM	4	integer	
Incorporation Depth:	DEPI	2	cm	
Record 17:	FILTRA			
	IPSCND			
	UPTKF			
Record 18:	PLVKRT			
	PLDKRT			
	FEXTRC			

Table III.E.5.14. PRZM/EXAMS Input Values for Fenamiphos Parent Compound Only

Property/ Parameter	PRZM Variable Name	Value	Units	Comments / References
Molecular weight	mwt	303.36	g/mol	EFED RED chapter
Henry's Law Const.	henry		atm-m ³ /mol	
Vapor Pressure	vapr	9.97E-10	torr	EFED RED chapter
Solubility	sol	400	mg/L	EFED RED chapter
Kd	Kd	0.958	mg/L	MRID 407748-08; lowest non-sand Kf
Koc	Koc		mg/L	
Photolysis half-life	kdp	75	days	MRID 40608001; corrected for dark control
Aerobic Aquatic Metabolism	kbacw	12	days	MRID 421493-03; 2x aerobic soil input parameter
Anaerobic Aquatic Metabolism	kbacs	399	days	MRID 412869-01; 6x anaerobic soil metabolism rate
Aerobic Soil Metabolism	asm	13.3	days	MRID 421493-03; 3x single value
Hydrolysis:	pH 5	247	days	MRID 421493-02; see Jones, RD, 2001, Revised Fenamiphos Est. Env. Conc.
Hydrolysis:	pH 7	300	days	MRID 421493-02; see Jones, RD, 2001, Revised Fenamiphos Est. Env. Conc.
Hydrolysis:	pH 9	231	days	MRID 421493-02; see Jones, RD, 2001, Revised Fenamiphos Est. Env. Conc.
Method:	CAM	4	integer	
Incorporation Depth:	DEPI	2	cm	
Record 17:	FILTRA			
	IPSCND			
	UPTKF			
Record 18:	PLVKRT			
	PLDKRT			
	FEXTRC			

Table III.E.5.15. PRZM/EXAMS Input Values for Malathion

Property/ Parameter	PRZM Variable Name	Value	Units	Comments / References
Molecular weight	mwt	330	g/mol	RED
Henry's Law Const.	henry	1.20E-07	atm-m ³ /mol	EFED One-liner
Vapor Pressure	vapr	4.00E-05	torr	EFED One-liner
Solubility	sol	145	mg/L	RED
Kd	Kd		mg/L	
Koc	Koc	151	mg/L	MRID 41345201
Photolysis half-life	kdp	156	days	MRID 41673001, 43166301 without acetone sensitizer
Aerobic Aquatic Metabolism	kbacw	3.27	days	MRID 42271601, 43163301 3x single value, value uncertain
Anaerobic Aquatic Metabolism	kbacs	7.5	days	MRID 42216301, 43166301 3x single value, value uncertain
Aerobic Soil Metabolism	asm	3	days	MRID 41721701, 43163301, see RED Appendix 3
Hydrolysis:	pH 5	107	days	MRID 40941201, 43166301
Hydrolysis:	pH 7	6.2	days	MRID 40941201, 43166301
Hydrolysis:	pH 9	0.5	days	MRID 40941201, 43166301
Method:	CAM	2	integer	
Incorporation Depth:	DEPI	0	cm	
Record 17:	FILTRA			
	IPSCND			
	UPTKF			
Record 18:	PLVKRT			
	PLDKRT			RED used 90% of dissipation values, should not have
	FEXTRC			

Table III.E.5.16. PRZM/EXAMS Input Values for Methamidophos

Property/ Parameter	PRZM Variable Name	Value	Units	Comments / References
Molecular weight	mwt	141.14	g/mol	EFGWB One-Liner
Henry's Law Const.	henry	1.60E-11	atm-m ³ /mol	Calculated
Vapor Pressure	vapr	1.73E-05	torr	MRID 43661003. At 24°C (Technical)
Solubility	sol	200000	mg/L	MRID 43661003.
Kd	Kd		mg/L	
Koc	Koc	1.5	mg/L	MRID 40504811. Only one Koc value available, adsorbed in only one of the five soils (clay loam) used in batch equilibrium studies.
Photolysis half-life	kdp	200.5	days	MRID 00150610; pH 5 (dark control-corrected)
Aerobic Aquatic Metabolism	kbacw	3.5	days	No data available; used 2x 162-1 (MRID 00014991)
Anaerobic Aquatic Metabolism	kbacs	0	days	No anaerobic aquatic metabolism data are available. Since significant hydrolysis occurs at pHs >5, assume compound is stable to aquatic metabolism.
Aerobic Soil Metabolism	asm	1.75	days	MRID 41372201; 3 X single value of 14 hours.
Hydrolysis:	pH 5	0	days	MRID 00150609
Hydrolysis:	pH 7	27	days	MRID 00150609
Hydrolysis:	pH 9	3.2	days	MRID 00150609
Method:	CAM	2	integer	
Incorporation Depth:	DEPI	0	cm	
Record 17:	FILTRA			
	IPSCND			
	UPTKF			
Record 18:	PLVKRT			
	PLDKRT			
	FEXTRC			

Table III.E.5.17. PRZM/EXAMS Input Values for Methidathion

Property/ Parameter	PRZM Variable Name	Value	Units	Comments / References
Molecular weight	mwt	302.3	g/mol	MRID
Henry's Law Const.	henry	3.97E-09	atm-m ³ /mol	MRID
Vapor Pressure	vapr	2.48E-06	torr	MRID
Solubility	sol	250	mg/L	MRID
Kd	Kd		mg/L	MRID
Koc	Koc	325	mg/L	MRID (00158529)
Photolysis half-life	kdp	11	days	MRID (42081709)
Aerobic Aquatic Metabolism	kbacw	39.8	days	(see asm, 2 x of asm value)MRID
Anaerobic Aquatic Metabolism	kbacs	20	days	(2 x soil anaerobic value) MRID (42262501)
Aerobic Soil Metabolism	asm	19.9	days	MRID (44545101, 4226501) 90%ile value
Hydrolysis:	pH 5	37	days	MRID (42037701, NOTE: pH 4 not 5)
Hydrolysis:	pH 7	48	days	MRID (42037701)
Hydrolysis:	pH 9	13	days	MRID (42037701)
Method:	CAM	2	integer	
Incorporation Depth:	DEPI	0	cm	
Record 17:	FILTRA			
	IPSCND			
	UPTKF			
Record 18:	PLVKRT			
	PLDKRT			
	FEXTRC			

Table III.E.5.18. PRZM/EXAMS Input Values for Methyl Parathion

Property/ Parameter	PRZM Variable Name	Value	Units	Comments / References
Molecular weight	mwt	265	g/mol	MRID
Henry's Law Const.	henry	6.12E-07	atm-m ³ /mol	MRID
Vapor Pressure	vapr	9.70E-06	torr	MRID
Solubility	sol	60	mg/L	MRID
Kd	Kd		mg/L	MRID
Koc	Koc	487	mg/L	MRID 40999001
Photolysis half-life	kdp	2.04	days	MRID 40809701
Aerobic Aquatic Metabolism	kbacw	12.3	days	MRID 41768901 3x single value
Anaerobic Aquatic Metabolism	kbacs	1.5	days	MRID 41768901 3x single value
Aerobic Soil Metabolism	asm	11.25	days	MRID 41735901 3x single value
Hydrolysis:	pH 5	68	days	MRID 0013275,40784501
Hydrolysis:	pH 7	40	days	MRID 0013275,40784501
Hydrolysis:	pH 9	33	days	MRID 0013275,40784501
Method:	CAM	2	integer	
Incorporation Depth:	DEPI	0	cm	
Record 17:	FILTRA			
	IPSCND			
	UPTKF			
Record 18:	PLVKRT			
	PLDKRT			simulated washoff 0.5 cm-1
	FEXTRC			

Table III.E.5.19. PRZM/EXAMS Input Values for Naled

Property/ Parameter	PRZM Variable Name	Value	Units	Comments / References
Molecular weight	mwt	381	g/mol	Merck
Henry's Law Const.	henry	1.13E-07	atm-m ³ /mol	Calculated
Vapor Pressure	vapr	4.50E-04	torr	
Solubility	sol	2000	mg/L	
Kd	Kd		mg/L	
Koc	Koc	180	mg/L	00161100, 40279200, 40394904, 41354104, 41354105 and 41354106
Photolysis half-life	kdp	69	days	41310702 and 42445103
Aerobic Aquatic Metabolism	kbacw	1.5	days	from RED
Anaerobic Aquatic Metabolism	kbacs	4.5	days	MRIDs 40618201, 41354102, 42445101
Aerobic Soil Metabolism	asm	1.00	days	85408
Hydrolysis:	pH 5	4	days	40034902 and 41354101
Hydrolysis:	pH 7	0.64	days	40034902 and 41354101
Hydrolysis:	pH 9	0.07	days	40034902 and 41354101
Method:	CAM		integer	
Incorporation Depth:	DEPI		cm	
Record 17:	FILTRA			
	IPSCND			
	UPTKF			
Record 18:	PLVKRT			
	PLDKRT			
	FEXTRC			

Table III.E.5.20. PRZM/EXAMS Input Values for Oxydemeton Methyl

Property/ Parameter	PRZM Variable Name	Value	Units	Comments / References
Molecular weight	mwt	246	g/mol	40620301
Henry's Law Const.	henry	9.26E-09	atm-m ³ /mol	Calculated
Vapor Pressure	vapr	2.86E-05	torr	42951203
Solubility	sol	1000	mg/L	42951203
Kd	Kd	0.45	mg/L	mrid 40884201
Koc	Koc		mg/L	
Photolysis half-life	kdp	466	days	mrid 40781501; corrected for dark control (137 in light, 194 in dark)
Aerobic Aquatic Metabolism	kbacw	19.2	days	no study; 2x aerobic soil metabolism input value
Anaerobic Aquatic Metabolism	kbacs	10.5	days	42901801 half-life *3
Aerobic Soil Metabolism	asm	9.6	days	MRID 42831501, 3.2 days x 3
Hydrolysis:	pH 5	93	days	MRID 001430547, hydraf was used
Hydrolysis:	pH 7	40	days	MRID 001430547, hydraf was used
Hydrolysis:	pH 9	2.5	days	MRID 001430547, hydraf was used
Method:	CAM		integer	T-band?
Incorporation Depth:	DEPI		cm	
Record 17:	FILTRA			
	IPSCND			
	UPTKF			
Record 18:	PLVKRT			
	PLDKRT			
	FEXTRC			

Table III.E.5.21. PRZM/EXAMS Input Values for Phorate Total Toxic Residues

Property/ Parameter	PRZM Variable Name	Value	Units	Comments / References
Molecular weight	mwt	260	g/mol	MRID 41297901; parent
Henry's Law Const.	henry	2.87E-08	atm-m ³ /mol	Calculated
Vapor Pressure	vapr	7.50E-04	torr	MRID 41049502; parent
Solubility	sol	8926	mg/L	MRID 41049501; sulfoxide
Kd	Kd	0.53	mg/L	MRID 44671204; sulfoxide/more mobile
Koc	Koc	91	mg/L	
Photolysis half-life	kdp	2	days	MRID 41348508
Aerobic Aquatic Metabolism	kbacw	11	days	MRID 44863002, total toxic half-life based on applied parent and degradates
Anaerobic Aquatic Metabolism	kbacs	53	days	41936002; 2x anaerobic soil metabolism value
Aerobic Soil Metabolism	asm	121	days	(Getzwin and Shanks, J. Econ. Entom. 63:52-58) (linear, total toxic half-life)
Hydrolysis:	pH 5	3	days	MRID 41348507
Hydrolysis:	pH 7	3	days	MRID 41348507
Hydrolysis:	pH 9	4	days	MRID 41348507
Method:	CAM	8	integer	Corn_ t-band (cam 7); cotton/peanuts cam 8
Incorporation Depth:	DEPI	2.5	cm	1.27 cm for cotton; 2.5 cm for corn, peanuts
Record 17:	FILTRA			
	IPSCND			
	UPTKF			
Record 18:	PLVKRT			
	PLDKRT			
	FEXTRC			

Table III.E.5.22. PRZM/EXAMS Input Values for Phorate Parent Compound Only

Property/ Parameter	PRZM Variable Name	Value	Units	Comments / References
Molecular weight	mwt	260	g/mol	41297901
Henry's Law Const.	henry	5.13E-07	atm-m ³ /mol	Calculated
Vapor Pressure	vapr	7.50E-04	torr	41049502
Solubility	sol	500	mg/L	41049501
Kd	Kd	4.04	mg/L	42208201
Koc	Koc		mg/L	
Photolysis half-life	kdp	2	days	41348508
Aerobic Aquatic Metabolism	kbacw	1.5	days	44863002; 3x single value
Anaerobic Aquatic Metabolism	kbacs	53	days	41936002; 2x anaerobic soil metabolism value
Aerobic Soil Metabolism	asm	8.3	days	(Getzwin and Shanks, J. Econ. Entom. 63:52-58) (non-linear, no adjustment of value)
Hydrolysis:	pH 5	3	days	MRID 41348507
Hydrolysis:	pH 7	3	days	MRID 41348507
Hydrolysis:	pH 9	4	days	MRID 41348507
Method:	CAM	7	integer	Corn_ t-band (cam 7); cotton/peanuts cam 8
Incorporation Depth:	DEPI	2.5	cm	1.27 cm for cotton; 2.5 cm for corn, peanuts
Record 17:	FILTRA			
	IPSCND			
	UPTKF			
Record 18:	PLVKRT			
	PLDKRT			
	FEXTRC			

Table III.E.5.23. PRZM/EXAMS Input Values for Phosmet

Property/ Parameter	PRZM Variable Name	Value	Units	Comments / References
Molecular weight	mwt	317.3	g/mol	RED
Henry's Law Const.	henry	7.50E-09	atm-m ³ /mol	RED (calculated)
Vapor Pressure	vapr	4.50E-07	torr	RED
Solubility	sol	25	mg/L	RED
Kd	Kd	8.2	mg/L	MRID 40599002; average of 4 (1.17, 12.4, 13.6, 15.8) values
Koc	Koc		mg/L	MRID
Photolysis half-life	kdp	0	days	MRID 42607901: Stable (hydrolysis likely mechanism of degradation)
Aerobic Aquatic Metabolism	kbacw	18	days	No study; value is 2x aerobic soil metabolism input value
Anaerobic Aquatic Metabolism	kbacs	30	days	No study; value is 2x anaerobic soil metabolism input value (MRID 41497801)
Aerobic Soil Metabolism	asm	9	days	MRID 00112304; 3x single half-life value (compare w/ field dissipation t1/2s of 5-19 da)
Hydrolysis:	pH 5	7.5	days	MRID 40394301
Hydrolysis:	pH 7	0.4	days	MRID 40394301
Hydrolysis:	pH 9	0.004	days	MRID 40394301
Method:	CAM	2	integer	aerial app (2) for alfalfa; air blast for fruit crops
Incorporation Depth:	DEPI		cm	
Record 17:	FILTRA			
	IPSCND			
	UPTKF			
Record 18:	PLVKRT			
	PLDKRT			
	FEXTRC			

Table III.E.5.24. PRZM/EXAMS Input Values for Phostebupirim

Property/ Parameter	PRZM Variable Name	Value	Units	Comments / References
Molecular weight	mwt	318.4	g/mol	
Henry's Law Const.	henry		atm-m ³ /mol	
Vapor Pressure	vapr	3.80E-05	torr	
Solubility	sol	5.5	mg/L	
Kd	Kd		mg/L	Kd ranged from 12.4 to 15.6
Koc	Koc	1779	mg/L	MRIDs 420054-69, -70; mean of 2674, 2137, 1024, 1281
Photolysis half-life	kdp	1.3	days	MRID 42005467; no degradation in dark control
Aerobic Aquatic Metabolism	kbacw	666	days	No study; value is 2x aerobic soil metabolism input value
Anaerobic Aquatic Metabolism	kbacs	558	days	No study; 2x anaerobic soil metabolism value (279 da, MRID 42005468)
Aerobic Soil Metabolism	asm	333	days	343 da @ 34x max rate (MRID 42005468); 55, 82, 343 da @ max label rate (MRID 44299803, supplemental) -- 90% CI on mean
Hydrolysis:	pH 5	47	days	MRID 42005465
Hydrolysis:	pH 7	45	days	MRID 42005465
Hydrolysis:	pH 9	41	days	MRID 42005465
Method:	CAM	7	integer	Granular; bands, t-bands, in-furrow
Incorporation Depth:	DEPI	0	cm	No incorporation modeled, 12/8/97 DW assessment
Record 17:	FILTRA			
	IPSCND			
	UPTKF			
Record 18:	PLVKRT			
	PLDKRT			
	FEXTRC			

Table III.E.5.25. PRZM/EXAMS Input Values for Profenofos

Property/ Parameter	PRZM Variable Name	Value	Units	Comments / References
Molecular weight	mwt	374	g/mol	MRID
Henry's Law Const.	henry	1.83E-08	atm-m ³ /mol	MRID
Vapor Pressure	vapr	6.70E-09	torr	MRID
Solubility	sol	2	mg/L	MRID
Kd	Kd	9.7	mg/L	MRID 416273-11 (average of 4.6, 7.5, 17 -- non-clay soils)
Koc	Koc		mg/L	MRID
Photolysis half-life	kdp	75	days	MRIDs 418799-01, 419390-02
Aerobic Aquatic Metabolism	kbacw	12	days	2x aerobic soil met. value; no aerobic aquatic study available
Anaerobic Aquatic Metabolism	kbacs	9	days	3x single value (3 da); MRID 422181-01
Aerobic Soil Metabolism	asm	6	days	3x single value (2 da); MRID 423343-02
Hydrolysis:	pH 5	108	days	MRIDs 416273-09, 419390-01
Hydrolysis:	pH 7	62	days	MRIDs 416273-09, 419390-01
Hydrolysis:	pH 9	0.3	days	MRIDs 416273-09, 419390-01
Method:	CAM	2	integer	2 for aerial spray; 7 for banded
Incorporation Depth:	DEPI	2.5	cm	
Record 17:	FILTRA			
	IPSCND			
	UPTKF			
Record 18:	PLVKRT			
	PLDKRT			
	FEXTRC			

Table III.E.5.26. PRZM/EXAMS Input Values for Terbufos Total Toxic Residues

Property/ Parameter	PRZM Variable Name	Value	Units	Comments / References
Molecular weight	mwt	288	g/mol	MRID 41297901; parent
Henry's Law Const.	henry	3.73E-08	atm-m ³ /mol	Calculated
Vapor Pressure	vapr	3.16E-04	torr	MRID 41049502; parent
Solubility	sol	3210	mg/L	MRID 41049501, for sulfoxide since it is the predominant toxic residue
Kd	Kd		mg/L	
Koc	Koc	58	mg/L	MRID 41373604; sulfoxide/sulfone
Photolysis half-life	kdp	1	days	MRID 161567
Aerobic Aquatic Metabolism	kbacw	23	days	44862502, total toxic terbufos half-life from applied compounds
Anaerobic Aquatic Metabolism	kbacs	34	days	41749801, total toxic residues
Aerobic Soil Metabolism	asm	129	days	00156853, linear degradation of total toxic residue
Hydrolysis:	pH 5	0	days	MRID 00087694; Bowman&Sans (1982) indicate metabolites stable @ acidic pH
Hydrolysis:	pH 7	0	days	MRID 00087694; Bowman&Sans (1982) indicate metabolites stable @ acidic pH
Hydrolysis:	pH 9	0	days	MRID 00087694; Bowman&Sans (1982) show rates of 41 da for sulfoxide + 32 da for sulfone; using aquatic metabolism data to capture hydrolysis + metabolism
Method:	CAM	7	integer	Corn, sorghum, beets CAM 7 (t-band)
Incorporation Depth:	DEPI	2.5	cm	Incorporated to 2.5 cm
Record 17:	FILTRA			
	IPSCND			
	UPTKF			
Record 18:	PLVKRT			
	PLDKRT			
	FEXTRC			

Table III.E.5.27. PRZM/EXAMS Input Values for Terbufos Parent Compound Only

Property/ Parameter	PRZM Variable Name	Value	Units	Comments / References
Molecular weight	mwt	288	g/mol	41297901
Henry's Law Const.	henry	2.39E-05	atm-m ³ /mol	Calculated
Vapor Pressure	vapr	3.16E-04	torr	41049502
Solubility	sol	5	mg/L	41049501
Kd	Kd		mg/L	
Koc	Koc	633	mg/L	41373604
Photolysis half-life	kdp	1	days	161567
Aerobic Aquatic Metabolism	kbacw	1.5	days	44672004; pond water only, upper 90th CI on mean
Anaerobic Aquatic Metabolism	kbacs	11.7	days	41749801
Aerobic Soil Metabolism	asm	5.6	days	00156853 (non-linear, no adjustment of value because of formation and decline)
Hydrolysis:	pH 5	12	days	MRID 00087694
Hydrolysis:	pH 7	13	days	MRID 00087694
Hydrolysis:	pH 9	14	days	MRID 00087694
Method:	CAM	7	integer	Corn, sorghum, beets CAM 7 (t-band)
Incorporation Depth:	DEPI	2.5	cm	incorp to 2.5 cm
Record 17:	FILTRA			
	IPSCND			
	UPTKF			
Record 18:	PLVKRT			
	PLDKRT			
	FEXTRC			

Table III.E.5.28. PRZM/EXAMS Input Values for Tribufos

Property/ Parameter	PRZM Variable Name	Value	Units	Comments / References
Molecular weight	mwt	314	g/mol	9/6/00 Updated DW memo from D. Spatz, D. Young
Henry's Law Const.	henry		atm-m ³ /mol	
Vapor Pressure	vapr	1.70E-06	torr	9/6/00 Updated DW memo from D. Spatz, D. Young
Solubility	sol	2.3	mg/L	9/6/00 Updated DW memo from D. Spatz, D. Young
Kd	Kd	76.9	mg/L	MRID 42350004; average of 4 (66.8, 60.6, 74.3, 106) values
Koc	Koc	9300	mg/L	9/6/00 Updated DW memo from D. Spatz, D. Young
Photolysis half-life	kdp	0	days	MRID 41719401: Stable
Aerobic Aquatic Metabolism	kbacw	1490	days	No study; value is 2x aerobic soil metabolism input value
Anaerobic Aquatic Metabolism	kbacs	150	days	MRID 43325504; 5-mo t _{1/2} , 9/6/00 Spatz/Young DW memo
Aerobic Soil Metabolism	asm	745	days	MRID 42007204; single value. (not x3 because of high value)
Hydrolysis:	pH 5	0	days	MRID 41618814: Stable
Hydrolysis:	pH 7	0	days	MRID 41618814: Stable
Hydrolysis:	pH 9	124	days	MRID 41618814
Method:	CAM		integer	See PRZM manual
Incorporation Depth:	DEPI		cm	
Record 17:	FILTRA			
	IPSCND			
	UPTKF			
Record 18:	PLVKRT			
	PLDKRT			
	FEXTRC			

III. Appendices

E. Water Appendix

6. Water Exposure Assessment: Application-Specific Input Parameters for PRZM/EXAMS by Region

The tables presented in this region summarize the region-specific input parameters for each of the crop-OP uses modeled in each region. For each chemical, the tables provide:

- ☐ PRZM scenario file name – the scenario input file, documented in Appendix III.E.7
- ☐ Crop on which the pesticide is used
- ☐ Application method (PRZM CAM variable) and the general application method documented in Appendix III.E.8
- ☐ Depth of incorporation, based on available information on usage in the chemical-specific risk assessments
- ☐ Application rate (kg/ha) based on the usage information documented in Appendix III.E.8
- ☐ Application efficiency, set according to USEPA OPP's input parameter guidance
- ☐ Spray drift fraction, documented in Appendix III.E.9
- ☐ Application date, based on usage, growth stage, and most active application period documented in Appendix III.E.8
- ☐ Interval between additional applications, if any, based on usage information documented in Appendix III.E.8

a. Region A (Florida) Application Parameters

Chemical	PRZM scenario file name	Crop/Use	App. Meth. (CAM)	Incorp. Depth (cm)	App. Rate (kg/ha)	Applic. Effic.	Spray Drift (1)	App. Date	Interval between apps (days)					
									1	2	3	4	5	6
Chlorpyrifos	FLsweetcornC	Corn	2 Aerial/ foliar	0	0.73	0.99	0.055 Aerial	15-Feb	228**					
Phorate + Degradates	FLsweetcornC	Corn	7 Ground/ at plant	2.5	1.44	1	0.85 Frac in top 2 cm	1-Sep						
Ethoprop	FLsugarcaneC	Sugarcane	4 Ground/ at plant	10	3.89	1	0 No Drift	1-Sep						
Phorate + Degradates	FLsugarcaneC	Sugarcane	4 Ground/ at plant	2.5	4.44	1	0 No Drift	1-Sep						
Chlorpyrifos	FLcitrusC	Grapefruit	2 Airblast/foliar	0	2.09	0.99	0.0087 Air Blast	1-Jan	45					
Chlorpyrifos	FLcitrusC	Orange	2 Airblast/foliar	0	0.63	0.99	0.0087 Air Blast	1-Jan	45					
Chlorpyrifos	FLcitrusC	Tangelo	2 Ground/ at plant	0	1.12	0.99	0.0049 Ground	1-Jan						
Chlorpyrifos	FLcitrusC	Tangerine	2 Airblast/foliar	0	0.80	0.99	0.0087 Air Blast	1-Jan	45					
Acephate	FLcucumberC	Peppers	2 Ground / foliar	0	0.84	0.99	0.0049 Ground	25-Jan	263***	51				
Methamidophos (Acephate degradate)	FLcucumberC	Peppers	2	0	0.21 acephate * 0.25	1	0 degradate	27-Jan	263***	51				
Diazinon	FLcucumberC	Lettuce	2 Ground/ foliar	0	0.77	0.99	0.0049 Ground	22-Jan	266***					
Diazinon	FLcucumberC	Tomato	2 Ground/ foliar	0	0.64	0.99	0.0049 Ground	23-Jan	282***					
Methamidophos	FLcucumberC	Tomato	2 Ground/ foliar	0	0.52	0.99	0.0049 Ground	19-Feb	255***	55				

(1) Spray drift load estimated using Ag-Drift.

*** To populate app dates, listed app dates in chronological order w/in year

b. Region B (Northwest) Application Parameters

Chemical	PRZM scenario file name	Crop/Use	App. Meth.. (CAM)	Incorp. Depth (cm)	App. Rate (kg/ha)	App. Effic.	Spray Drift (1)	App.Date	Interval between applications (days)					
									1	2	3	4	5	6
Azinphos Methyl	ORappleC	Apples	2 Ground/ Foliar	0	0.99	0.99	0.0087 Airblast	1-May	41	41				
Chlorpyrifos	ORappleC	Apples	2 Ground/ Dormant	0	2.04	0.99	0.0087 Airblast	1-Feb						
Diazinon	ORappleC	Apples	2 Airblast/ Foliar	0	0.72	0.99	0.0087 Airblast	1-Feb	103					
Dimethoate	ORappleC	Apples	2 Airblast/ Foliar	0	0.85	0.99	0.0087 Airblast	1-May						
Malathion	ORappleC	Apples	2 Airblast/ Foliar	0	1.04	0.99	0.0087 Airblast	1-May	31					
Phosmet	ORappleC	Apples	2 Airblast/ Foliar	0	2.49	0.99	0.0087 Airblast	1-May	61					
Azinphos Methyl	ORappleC	Pears	2 Airblast/ Foliar	0	1.08	0.99	0.0087 Airblast	15-Apr	61					
Chlorpyrifos	ORappleC	Pears	2 Airblast/ Dormant	0	2.24	0.99	0.0087 Airblast	1-Feb						
Methidathion	ORappleC	Pears	2 Airblast/ Dormant	0	1.45	0.99	0.0087 Airblast	1-Feb						
Phosmet	ORappleC	Pears	2 Airblast/ Foliar	0	3.17	0.99	0.0087 Airblast	15-Apr	61					
Diazinon	ORappleC	Pears	2 Airblast/ Foliar	0	1.15	0.99	0.0087 Airblast	15-May						
Azinphos Methyl	ORappleC	Cherry, Sweet	2 Airblast/ Foliar	0	0.97	0.99	0.0087 Airblast	15-May						
Chlorpyrifos	ORappleC	Cherry, Sweet	2 Airblast/ Dormant	0	2.44	0.99	0.0087 Airblast	1-Feb						
Diazinon	ORappleC	Cherry, Sweet	2 Airblast/ Dormant	0	1.08	0.99	0.0087 Airblast	1-Feb						
Dimethoate	ORappleC	Cherry, Sweet	2 Airblast/ Foliar	0	0.90	0.99	0.0087 Airblast	15-Apr						

Chemical	PRZM scenario file name	Crop/Use	App. Meth.. (CAM)	Incorp. Depth (cm)	App. Rate (kg/ha)	App. Effic.	Spray Drift (1)	App.Date	Interval between applications (days)					
									1	2	3	4	5	6
Dimethoate	ORappleC	Cherries, Tart	2 Airblast/ Foliar	0	1.01	0.99	0.0087 Airblast	15-Apr						
Diazinon	ORappleC	Cherries, Tart	2 Airblast/ Foliar	0	1.01	0.99	0.0087 Airblast	1-Feb						
Phosmet	ORappleC	Cherries, Tart	2 Airblast/ Foliar	0	1.78	0.99	0.0087 Airblast	15-May	23					
Chlorpyrifos	ORfilbertsQ	Hazelnuts	2 Airblast/ Foliar	0	1.38	0.99	0.0087 Airblast	15-Apr						
Chlorpyrifos	ORswcorn	Sweet Corn	4 Ground / At-plant	5	1.48	1.00	0.0049 Ground	15-Apr						
Diazinon	ORsnbeansC	Beans, snap	2 Ground/ foliar	0	0.61	0.99	0.0049 Ground	15-Jun						
Ethoprop	ORsnbeansC	Beans, snap	2 Ground/ at-plant	0	2.69	1 Granular	0 Granular	30-Apr						
Dimethoate	ORsnbeansC	Peas, green	2 Ground/ foliar	0	0.20	0.99	0.0049 Ground	1-May						
Diazinon	ORsnbeansC	Peas, green	2 Ground/ foliar	0	0.56	0.99	0.0049 Ground	1-May						
Bensulide	ORsnbeansC	Broccoli	1 Ground/ at plant	0	4.04	0.99	0.0049 Ground	1-May						
Chlorpyrifos	ORsnbeansC	Broccoli	4 Ground/ at plant	5	1.42	0.99	0.0049 Ground	1-May						
Diazinon	ORsnbeansC	Broccoli	2 Ground/ foliar	0	0.90	0.99	0.0049 Ground	1-Jul						
Disulfoton + degradates	ORsnbeansC	Broccoli	2 Ground/ foliar	0	1.13	0.99	0.0049 Ground	1-Jul						
Naled	ORsnbeansC	Broccoli	2 Ground/ foliar	0	1.55	0.99	0.0049 Ground	1-Jul						
DDVP (naled degr)	ORsnbeansC	Broccoli	2 Degradate	0	0.31 naled * 0.2	1.00	0 degradate	1-Jul						
Bensulide	ORsnbeansC	Cabbage	1 Ground/ at plant	0	4.24	0.99	0.0049 Ground	15-Mar						
Chlorpyrifos	ORsnbeansC	Cabbage	4 Ground/ at plant	5	0.74	0.99	0.0049 Ground	15-Mar						
Dimethoate	ORsnbeansC	Cabbage	2	0	0.53	0.99	0.0049	15-Jul	23					

Chemical	PRZM scenario file name	Crop/Use	App. Meth.. (CAM)	Incorp. Depth (cm)	App. Rate (kg/ha)	App. Effic.	Spray Drift (1)	App.Date	Interval between applications (days)					
									1	2	3	4	5	6
			Ground/ foliar				Ground							
ODM	ORsnbeansC	Cabbage	2 Ground/ foliar	0	0.63	0.99	0.0049 Ground	15-Jul	23					
Acephate	ORsnbeansC	Cauliflower	2 Ground/ foliar	0	0.93	0.99	0.0049 Ground	15-Aug						
Methamidophos (acephate degradate)	ORsnbeansC	Cauliflower	2 Degradate	0	0.23 acephate * 0.25	1.00	0	17-Aug						
Diazinon	ORsnbeansC	Cauliflower	2 Ground/ foliar	0	0.60	0.99	0.0049 Ground	15-Aug	31					
Dimethoate	ORsnbeansC	Cauliflower	2 Ground/ foliar	0	0.44	0.99	0.0049 Ground	15-Aug						
Naled	ORsnbeansC	Cauliflower	2 Ground/ foliar	0	1.57	0.99	0.0049 Ground	15-Aug						
DDVP (naled degradate)	ORsnbeansC	Cauliflower	2 Degradate	0	0.31 naled * 0.2	1.00	0	15-Aug						
Bensulide	ORsnbeansC	Cucumbers	1 Ground/ at plant	0	3.60	0.99	0.0049 Ground	10-May						
Malathion	ORsnbeansC	Squash	2 Ground/ foliar	0	1.59	0.99	0.0049 Ground	1-Jul	15					
Chlorpyrifos	ORsnbeansC	Onions	4 Ground/ at plant	5	1.13	0.99	0.0049 Ground	20-Mar						
Diazinon	ORsnbeansC	Onions	2 Ground/ foliar	0	0.89	0.99	0.0049 Ground	1-Jul						
Malathion	ORsnbeansC	Onions	2 Ground/ foliar	0	2.06	0.99	0.0049 Ground	1-Jul	31					
MethylParathion	ORsnbeansC	Onions	2 Ground/ foliar	0	0.56	0.99	0.0049 Ground	1-Jul	31					
Chlorpyrifos	ORgrasseed C	Grass for seed	2 Ground/ foliar	0	1.11	0.99	0.0049 Ground	1-Apr						
Chlorpyrifos	ORXmasTree	Christmas Trees	2 Airblast/ foliar	0	1.11	0.99	0.0087 Airblast	1-May						
Dimethoate	ORXmasTree	Christmas Trees	2 Airblast/ foliar	0	0.56	0.99	0.0087 Airblast	1-May						

Chemical	PRZM scenario file name	Crop/Use	App. Meth.. (CAM)	Incorp. Depth (cm)	App. Rate (kg/ha)	App. Effic.	Spray Drift (1)	App.Date	Interval between applications (days)					
									1	2	3	4	5	6
ODM	ORXmasTree	Christmas Trees	2 Airblast/ foliar	0	0.42	0.99	0.0087 Airblast	15-Apr						
Acephate	ORXmasTree	Nursery/Tree s-Shrubs	2 Ground/ foliar	0	1.11	0.99	0.0049 Ground	1-Apr						
Methamidophos (acephate degradate)	ORXmasTree	Nursery/Tree s-Shrubs	2 Degradate	0	0.28 acephate * 0.25	1.00	0	3-Apr						
Chlorpyrifos	ORXmasTree	Nursery/Tree s-Shrubs	2 Ground/ foliar	0	1.11	0.99	0.0049 Ground	1-Apr						
Diazinon	ORXmasTree	Nursery/Tree s-Shrubs	2 Ground/ foliar	0	0.77	0.99	0.0049 Ground	1-Apr						
Diazinon	ORhopsC	Hops	2 Ground/ foliar	0	1.11	0.99	0.0049 Ground	1-Jun	31	31				
Acephate	ORmintC	Mint	2 Ground/ foliar	0	1.08	0.99	0.0049 Ground	15-Jul						
Methamidophos (acephate degradate)	ORmintC	Mint	2 Degradate	0	0.27 acephate * 0.25	1.00	0	17-Jul						
Chlorpyrifos	ORmintC	Mint	2 Ground/ foliar	0	2.10	0.99	0.0049 Ground	20-Aug						
AzinphosMethyl	ORberriesC	Blackberry	2 Ground/ foliar	0		0.99	0.0049 Ground	1-Apr						
Diazinon	ORberriesC	Blackberry	2 Ground/ foliar	0	1.29	0.99	0.0049 Ground	15-Mar						
Diazinon	ORberriesC	Blueberry	2 Ground/ foliar	0	0.89	0.99	0.0049 Ground	1-Mar						
Malathion	ORberriesC	Blueberry	2 Ground/ foliar	0	1.80	0.99	0.0049 Ground	1-Apr	62					
Diazinon	ORberriesC	Raspberry	2 Ground/ foliar	0	1.18	0.99	0.0049 Ground	1-Mar						
Malathion	ORberriesC	Raspberry	2 Ground/ foliar	0	2.29	0.99	0.0049 Ground	1-May						

(1) Spray drift load estimated using Ag-Drift.

c. Region C (Arid/Semiarid West): Application Parameters

Chemical	PRZM scenario file name	Crop/Use	App. Meth. (CAM)	Incorp. Depth (cm)	App. Rate	App. Effic.	Spray Drift	App. Date	Interval between applications (days)					
									1	2	3	4	5	6
AzinphosMethyl	CAalmondC	Almonds, walnuts	2 Air29%, Grd 71%	0	1.73	0.99	0.0087 Airblast	12-Jul	7	1	6	1		
Chlorpyrifos	CAalmondC	Almonds, walnuts	2 Air 8%, Grd 92%	0	1.89	0.99	0.0087 Airblast	10-May	7	21	49	7		
Diazinon	CAalmondC	Almonds, walnuts	2 Air21%, Grd 79%	0	2.08	0.99	0.0087 Airblast	11-Jan	7	14	1	6		
Methidathion	CAalmondC	Almonds, walnuts	2 Air 8%, Grd 92%	0	1.08	0.99	0.0087 Airblast	11-Jan	7	1	6	7		
Naled	CAalmondC	Almonds, walnuts	2 Air0%, Grd 100%	0	1.78	0.99	0.0087 Airblast	18-Jan	6	1	1	6		
DDVP (Naled degradate)	CAalmondC	Almonds, walnuts	2 Naled*0.2	0	0.36	1	0 Degradate	18-Jan	6	1	1	6		
Phosmet	CAalmondC	Almonds, walnuts	2 Air 7%, Grd 93%	0	3.17	0.99	0.0087 Airblast	22-Mar	119	7	7	7		
Chlorpyrifos	CAalfalfaC	Alfalfa	2 Air85%, Grd 15%	0	0.63	0.99	0.055 Aerial	8-Mar	7	7	35	126		
Dimethoate	CAalfalfaC	Alfalfa	2 Air80%, Grd 20%	0	0.39	0.99	0.055 Aerial	8-Mar	7	7	7	49		
Malathion	CAalfalfaC	Alfalfa	2 Air83%, Grd 17%	0	1.26	0.99	0.055 Aerial	22-Mar	7	7	7	7		
MethylParathion	CAalfalfaC	Alfalfa	2 Air88%, Grd 12%	0	0.93	0.99	0.055 Aerial	7-Mar	1	1	6	7		
Phosmet	CAalfalfaC	Alfalfa	2 Air80%, Grd 21%	0	0.8	0.99	0.055 Aerial	8-Mar	7	1	6	7		
AzinphosMethyl	CAfruitC	Apples, pears	2 Air 6%, Grd 94%	0	1.16	0.99	0.0087 Airblast	24-May	21	7	28	35		
Chlorpyrifos	CAfruitC	Apples, pears	2 Air 8%, Grd 92%	0	1.46	0.99	0.0087 Airblast	8-Mar	49	7	21	28		
Diazinon	CAfruitC	Apples, pears	2	0	1.67	0.99	0.0087	25-Jan	42	1	6	154		

Chemical	PRZM scenario file name	Crop/Use	App. Meth. (CAM)	Incorp. Depth (cm)	App. Rate	App. Effic.	Spray Drift	App. Date	Interval between applications (days)					
									1	2	3	4	5	6
			Air 1%, Grd 99%				Airblast							
Dimethoate	CAfruitC	Apples, pears	2	0	0.64	0.99	0.0087	18-Apr	1	1	20	28		
			Air 0%, Grd100%				Airblast							
Methidathion	CAfruitC	Apples, pears	2	0	1.28	0.99	0.0087	18-Jan	7	28	7	7		
			Air 0%, Grd100%				Airblast							
Phosmet	CAfruitC	Apples, pears	2	0	3.35	0.99	0.0087	17-May	14	35	21	28		
			Air 15%, Grd85%				Airblast							
Chlorpyrifos	CAfruitC	Peaches, nectarines, apricots	2	0	2.03	0.99	0.0087	25-Jan	1	6	318	1		
			Air 1%, Grd99%				Airblast							
Diazinon	CAfruitC	Peaches, nectarines, apricots	2	0	2.34	0.99	0.0087	22-Nov	1	14	14	7		
			Air 3%, Grd97%				Airblast							
Dimethoate	CAfruitC	Peaches, nectarines, apricots	2	0	4.01	0.99	0.0087	5-Jun	1	1	1	1		
			Air 0%, Grd100%				Airblast							
Methidathion	CAfruitC	Peaches, nectarines, apricots	2	0	1.3	0.99	0.0087	18-Jan	42	280	14	1		
			Air 3%, Grd97%				Airblast							
Naled	CAfruitC	Peaches, nectarines, apricots	2	0	1.82	0.99	0.0087	4-Jan	1	12	1	1		
			Air 0%, Grd100%				Airblast							
DDVP	CAfruitC	Peaches, nectarines, apricots	2	0	0.36	1	0	4-Jan	1	12	1	1		
			Air 0%, Grd100%		Naled*0.2 (RED)		Degradate							
Phosmet	CAfruitC	Peaches, nectarines, apricots	2	0	3.09	0.99	0.0087	31-May	7	7	21	14		
			Air 2%, Grd98%				Airblast							
Chlorpyrifos	CAtomatoC	Asparagus	2	0	0.72	0.99	0.055	5-Jul	21	7	42	35		
			Air 51%, Grd49%				Aerial							
DisulfotonT	CAtomatoC	Asparagus	2	0	1.18	0.99	0.055	9-Aug	28	14	14	7		
			Air 67%, Grd33%				Aerial							
Malathion	CAtomatoC	Asparagus	2	0	1.11	0.99	0.055	6-Jun	1	1	13	7		
			Air 46%, Grd54%				Aerial							

Chemical	PRZM scenario file name	Crop/Use	App. Meth. (CAM)	Incorp. Depth (cm)	App. Rate	App. Effic.	Spray Drift	App. Date	Interval between applications (days)					
									1	2	3	4	5	6
Acephate	CAtomatoC	Legume (dry/succulent beans)	2	0	0.96	0.99	0.055	2-Aug	7	7	14	7		
			Air 95%, Grd5%				Aerial							
Methamidophos (acephate degradate)	CAtomatoC	Legume (dry/succulent beans)	2	0	0.24	1	0	4-Aug	7	7	14	7		
			Air 95%, Grd5%		Aceph*0.25 (RED)		Degradate	Aceph + 2 days						
Dimethoate	CAtomatoC	Legume (dry/succulent beans)	2	0	0.45	0.99	0.055	19-Jul	14	7	21	14		
			Air 87%, Grd13%				Aerial							
Malathion	CAtomatoC	Legume (dry/succulent beans)	2	0	1.19	0.99	0.055	28-Jun	35	7	1	6		
			Air 78%, Grd16%				Aerial							
Naled	CAtomatoC	Legume (dry/succulent beans)	2	0	0.97	0.99	0.055	30-Aug	7	7	1	13		
			Air 93%, Grd7%				Aerial							
DDVP	CAtomatoC	Legume (dry/succulent beans)	2	0	0.19	1	0	30-Aug	7	7	1	13		
			Air 93%, Grd7%		Naled*0.2 (RED)		Degradate							
Diazinon	CAtomatoC	Broccoli, brassicas	2	0	1.12	0.99	0.0049	16-Aug	1	1	1	1		
			Ground				Ground							
Dimethoate	CAtomatoC	Broccoli, brassicas	2	0	0.4	0.99	0.055	16-Aug	14	7	7	28		
			Air 54%, Grd46%				Aerial							
Methamidophos	CAtomatoC	Broccoli, brassicas	2	0	1.67	0.99	0.055	6-Sep	20	1	1	20		
			Air 60%, Grd40%				Aerial							
ODM	CAtomatoC	Broccoli, brassicas	2	0	0.56	0.99	0.055	11-Jan	35	244	1	1		
			Air 45%, Grd55%				Aerial							
Diazinon	CAtomatoC	Cantaloupe	2	0	0.38	0.99	0.055	17-May	7	69	1	1		
			Air 49%, Grd48%				Aerial							
Dimethoate	CAtomatoC	Cantaloupe	2	0	0.54	0.99	0.055	2-Aug	1	6	1	7		
			Air 69%, Grd31%				Aerial							
ODM	CAtomatoC	Cantaloupe	2	0	0.42	0.99	0.055	24-Jul	1	1	1	1		
			Air 66%, Grd34%				Aerial							
Acephate	CAtomatoC	Tomato	2	0	0.91	0.99	0.055	9-Aug	1	20	1	6		
			Air 58%, Grd42%				Aerial							

Chemical	PRZM scenario file name	Crop/Use	App. Meth. (CAM)	Incorp. Depth (cm)	App. Rate	App. Effic.	Spray Drift	App. Date	Interval between applications (days)					
									1	2	3	4	5	6
Methamidophos (acephate degradate)	CAtomatoC	Tomato	2	0	0.23	0.99	0	11-Aug	1	20	1	6		
			Air 58%, Grd42%		Aceph*0.25 (RED)		Degradate	Aceph + 2 days						
Chlorpyrifos	CAtomatoC	Tomato	2	0	0.67	0.99	0.0049	12-Jul	21	1	20	1		
			Air 12%, Grd88%				Ground							
Diazinon	CAtomatoC	Tomato	2	0	1.23	0.99	0.0049	8-Mar	56	14	7	49		
			Air 4%, Grd96%				Ground							
Dimethoate	CAtomatoC	Tomato	2	0	0.49	0.99	0.055	5-Jul	14	7	7	21		
			Air 71%, Grd29%				Aerial							
Malathion	CAtomatoC	Tomato	2	0	1.32	0.99	0.055	26-Jul	1	6	1	13		
			Air 56%, Grd44%				Aerial							
Methamidophos	CAtomatoC	Tomato	2	0	0.95	0.99	0.055	12-Jul	14	21	21	21		
			Air 51%, Grd49%				Aerial							
Chlorpyrifos	CAalfalfaC	Alfalfa	2	0	0.63	0.99	0.055	8-Mar	7	7	35	126		
			Air 85%, Grd15%				Aerial							
Dimethoate	CAalfalfaC	Alfalfa	2	0	0.39	0.99	0.055	8-Mar	7	7	7	49		
			Air 80%, Grd20%				Aerial							
Malathion	CAalfalfaC	Alfalfa	2	0	1.26	0.99	0.055	22-Mar	7	7	7	7		
			Air 83%, Grd17%				Aerial							
MethylParathion	CAalfalfaC	Alfalfa	2	0	0.93	0.99	0.055	7-Mar	1	1	6	7		
			Air 88%, Grd12%				Aerial							
Phosmet	CAalfalfaC	Alfalfa	2	0	0.8	0.99	0.055	8-Mar	7	1	6	7		
			Air 80%, Grd21%				Aerial							
Chlorpyrifos	CAcornC	FieldCorn	2	0	1.27	0.99	0.0049	17-May	21	7	14	14		
			Air 18%, Grd82%				Ground							
Dimethoate	CAcornC	FieldCorn	2	0	0.36	0.99	0.055	13-Mar	1	1	1	90		
			Air 74%, Grd26%				Aerial							
Malathion	CAcornC	FieldCorn	2	0	0.56	0.99	0.055	22-Mar	1	13	133	7		
			Air 89%, Grd11%				Aerial							
PhorateT	CAcornC	FieldCorn	7	2.5	1.31	1	0.85	3-May	14	14	7	7		
			Air 0%, Grd100%				Fraction in upper 2 cm							
Chlorpyrifos	CAgrapesC	Grapes	2	0	2.08	0.99	0.0012	7-Mar	1	1	6	1		
			Air 0%, Grd99%				Vineyard							
Diazinon	CAgrapesC	Grapes	2	0	0.38	0.99	0.0012	17-May	83	1	1	1		
			Air 0%, Grd99%				Vineyard							
Dimethoate	CAgrapesC	Grapes	2	0	0.32	0.99	0.0012	17-Jul	1	1	1	1		

Chemical	PRZM scenario file name	Crop/Use	App. Meth. (CAM)	Incorp. Depth (cm)	App. Rate	App. Effic.	Spray Drift	App. Date	Interval between applications (days)					
									1	2	3	4	5	6
			Air 0%, Grd99%				Vineyard							
Malathion	CAgrapesC	Grapes	2	0	32.37	0.99	0.0012	19-Jun	1	1	1	1		
			Air 6%, Grd94%				Vineyard							
Naled	CAgrapesC	Grapes	2	0	0.75	0.99	0.0012	21-Jun	28	14	7	28		
			Air 6%, Grd94%				Vineyard							
DDVP	CAgrapesC	Grapes	2	0	0.15	0.99	0	21-Jun	28	14	7	28		
			Air 6%, Grd94%		Naled*0.2 (RED)		Degradate							
Chlorpyrifos	CA sugarbeet C	Sugarbeet	2	0	0.69	0.99	0.055	17-Mar	70	21	21	7		
			Air 78%, Grd22%				Aerial							
Methamidophos	CA sugarbeet C	Sugarbeet	2	0	0.82	0.99	0.055	10-May	84	7	7	49		
			Air 88%, Grd12%				Aerial							
Naled	CA sugarbeet C	Sugarbeet	2	0	1.13	0.99	0.055	18-Sep	1	1	1	1		
			Air 91%, Grd9%				Aerial							
DDVP	CA sugarbeet C	Sugarbeet	2	0	0.23	0.99	0	18-Sep	1	1	1	1		
			Air 91%, Grd9%		Naled*0.2 (RED)		Degradate							
ODM	CA sugarbeet C	Sugarbeet	2	0	0.49	0.99	0.055	19-Apr	1	6	133	14		
			Air 88%, Grd12%				Aerial							
PhorateT	CA sugarbeet C	Sugarbeet	7	2.5	0.27	1	0.85	10-Apr	1	1	1	1		
			Air 2%, Grd98%				Fraction in upper 2 cm							

(1) Spray drift load estimated using Ag-Drift.

d. Region D (Northeast/ North Central): Application Parameters

Chemical	PRZM scenario file name	Crop/Use	App. Meth. (CAM)	Incorp. Depth (cm)	App. Rate	App. Effic.	Spray Drift	App. Date	Interval between applications (days)						
									1	2	3	4	5	6	
AzinphosMethyl	MNsugarbeetC	Potato	Aerial/ foliar	2	0	0.53	0.99	0.055	31-Jul						
Dimethoate	MNsugarbeetC	Potato	Aerial foliar	2	0	0.30	0.99	0.055	31-Jul						
Chlorpyrifos	MNsugarbeetC	Sugar beet	Ground/ plant; gen w/ incorp	4	5	1.39	0.99	0.0049	10-May						
Phorate+ degradates	MNsugarbeetC	Sugar beet	Ground/ plant	7	2	1.14	1	0.85	10-May						
Terbufos+ degradates	MNsugarbeetC	Sugar beet	Ground/ plant	7	2	2.19	1	0.85	10-May						
Chlorpyrifos	NDwheatC	Wheat	Aerial/ foliar	2	0	0.56	0.99	0.055	3-Jul						

(1) Spray drift load estimated using Ag-Drift.

e. Region E (Humid Southeast): Application Parameters

Chemical	PRZM scenario file name	Crop/Use	App. Meth. (CAM)	Incorp. Depth (cm)	App. Rate	App. Effic.	Spray Drift	App. Date	Interval between applications (days)					
									1	2	3	4	5	6
Terbufos + Residues	NCcornEC	Corn	7 In-furrow	2.5	1.27	1	0.85 Frac in top 2 cm	17-Apr						
Chlorpyrifos	NCcornEC	Corn	2 Ground/ broadcast or before wheel	0	1.30	0.99	0.0049 Ground	17-Apr						
Acephate	NCcottonC	Cotton	2 Broadcast	0	0.30	0.99	0.0049 Ground	11-Jun						
Methamidophos (Acephate degradate)	NCcottonC	Cotton	2 acephate degr	0	0.07 aceph*0.25	0.99	0 Off-set, 2-da t1/2	13-Jun						
Dimethoate	NCcottonC	Cotton	2 Broadcast	0	0.11	0.99	0.0049 Ground	1-May	41					
Phorate + Residues	NCcottonC	Cotton	8 Banded	1.27	1.00	1	0 No drift	10-May						
Tribufos	NCcottonC	Cotton	2 Broadcast	0	0.51	0.99	0.0049 Ground	19-Oct						
Disulfoton + Residues	NCcottonC	Cotton	7 Banded	2.5	0.73	1	0.85 Frac in top 2 cm	10-May						
Acephate	NCpeanutC	Peanut	2 Aerial or ground/ broadcast	0	0.52	0.99	0.0049 Ground	25-May						
Methamidophos (Acephate degradate)	NCpeanutC	Peanut	2 acephate degr	0	0.13 aceph*0.25	1	0 Off-set, 2-da t1/2	27-May						
Chlorpyrifos	NCpeanutC	Peanut	2 Banded	0	0.70	0.99	0.0049 Ground	7-Jul						

Chemical	PRZM scenario file name	Crop/Use	App. Meth. (CAM)	Incorp. Depth (cm)	App. Rate	App. Effic.	Spray Drift	App. Date	Interval between applications (days)					
									1	2	3	4	5	6
Phorate + Residues	NCpeanutC	Peanut	7	2.5	1.00	1	0.85	18-May						
			Banded				Frac in top 2 cm							
Acephate	NCtobaccoC	Tobacco	2	0	0.83	0.99	0.0049	30-Jun						
			Ground broadcast				Ground							
Methamidophos (Acephate degradate)	NCtobaccoC	Tobacco	2	0	0.21	1	0	2-Jul						
			Ground broadcast		aceph*0.25									
Chlorpyrifos	NCtobaccoC	Tobacco	2	0	2.55	0.99	0.0049	16-May						
			Aerial or ground/ broadcast		NASS (1996)	**	Ground							

(1) Spray drift load estimated using Ag-Drift.

f. Region F (Lower Midwest): Application Parameters

Chemical	PRZM scenario file name	Crop/Use	App. Meth. (CAM)	Incorp. Depth (cm)	Appl. Rate	App. Effic.	Spray Drift	App. Date	Interval between applications (days)					
									1	2	3	4	5	6
Chlorpyrifos	TXalfalfaC	Alfalfa	2	0	0.61	0.99	0.055 Aerial	16-Jun						
MethylParathion	TXalfalfaC	Alfalfa	2	0	0.21	0.99	0.055 Aerial	16-Jun						
Chlorpyrifos	TXcornC	Corn	4	5	0.84	1	0.0049 Ground	9-Apr						
Dimethoate	TXcornC	Corn	2	0	0.48	0.99	0.055 Aerial	1-Jul						
Phostebupirim	TXcornC	Corn	7	2.5	0.09	1	0.85 Fraction in upper 2 cm	9-Apr						
Terbufos + degradates	TXcornC	Corn	7	2.5	0.91	1	0.85 Fraction in upper 2 cm	9-Apr						
Acephate	TXcottonC	Cotton	2	0	0.63	0.99	0.0049 Ground	1-May	20					
Methamidophos (acephate Degradate)	TXcottonC	Cotton	2	0	0.16 acephate* 0.25	1	0	3-May	20					
Chlorpyrifos	TXcottonC	Cotton	Prairie / TX	0	0.71	0.99	0.055	15-Jun	31					
Dicrctophos	TXcottonC	Cotton	Prairie / TX	0	0.16	0.99	0.0049 Ground	1-May	23					
Dimethoate	TXcottonC	Cotton	Prairie / TX	0	0.27	0.99	0.0049 Ground	1-May	23					
Malathion	TXcottonC	Cotton	Prairie / TX	0	1.13	0.99	0.0049 Ground	15-May						
Malathion	TXcottonC	Cotton	Prairie / TX	0	1.13	0.99	0.055 Aerial	6-Jun	22	22	22	22	22	

Chemical	PRZM scenario file name	Crop/Use	App. Meth. (CAM)	Incorp. Depth (cm)	Appl. Rate	App. Effic.	Spray Drift	App. Date	Interval between applications (days)					
									1	2	3	4	5	6
Phorate + degradates	TXcottonC	Cotton	Ground/ plant	7	2.5	0.49	1	0.85	13-Apr					
								Fraction in upper 2 cm						
Tribufos	TXcottonC	Cotton	Air/ Harvest	2	0	0.57	0.99	0.055	1-Nov					
								Aerial						
Chlorpyrifos	TXsorghumC	Sorghum	Aerial/ foliar	2	0	0.49	0.99	0.055	2-May					
								Aerial						
Dimethoate	TXwheatC	Wheat	Aerial/ foliar	2	0	0.31	0.99	0.055	8-Nov					
								Aerial						

(1) Spray drift load estimated using Ag-Drift.

g. Region G (Mid-South): Application Parameters

Chemical	PRZM scenario file name	Crop/Use	App. Meth. (CAM)	Incorp. Depth (cm)	App. Rate	Appl. Effic.	Spray Drift	App. Date	Interval between applications (days)						
									1	2	3	4	5	6	
Chlorpyrifos	MScornC	Corn	Ground plant	4	5	0.84	0.99	0.0049	27-Mar						
Dimethoate	MScornC	Corn	Aerial foliar	2	0	0.48	0.99	0.055	23-Jun						
Phostebupirim	MScornC	Corn	Ground plant	7	2.5	0.09	1	0.85	27-Mar						
Terbufos + Degradates	MScornC	Corn	Ground plant	7	2.5	0.91	1	0.85	27-Mar						
Acephate	MScottonC	Cotton	Ground/ plant-foliar	2	0	0.39	0.99	0.0049	6-May						
Methamidophos (acephate degradate)	MScottonC	Cotton	Ground/ plant-foliar	2	0	0.10	1	0	8-May						
Acephate	MScottonC	Cotton	Aerial/ foliar	2	0	0.39	0.99	0.055	24-Jun						
Methamidophos (acephate degradate)	MScottonC	Cotton	Aerial/ foliar	2	0	0.10	1	0	26-Jun						
Dicrotophos	MScottonC	Cotton	Ground/ foliar	2	0	0.30	0.99	0.0049	1-May						
Dicrotophos	MScottonC	Cotton	Aerial/ foliar	2	0	0.30	0.99	0.055	1-Jul						
Dimethoate	MScottonC	Cotton	Ground/ foliar	2	0	0.29	0.99	0.0049	15-Jun						
Dimethoate	MScottonC	Cotton	Aerial/ foliar	2	0	0.29	0.99	0.055	8-Jul						
Malathion	MScottonC	Cotton		2	0	0.97	0.99	0.0049	1-May	19	19				

Chemical	PRZM scenario file name	Crop/Use	App. Meth. (CAM)	Incorp. Depth (cm)	App. Rate	Appl. Effic.	Spray Drift	App. Date	Interval between applications (days)					
									1	2	3	4	5	6
			Ground/ foliar				Ground							
Malathion	MScottonC	Cotton	2 Aerial/ foliar	0	0.97	0.99	0.055	27-Jun	19	19	19	19		
Methamidophos	MScottonC	Cotton	2 Aerial/ foliar	0	0.42	0.99	0.055	1-Jul						
MethylParathion	MScottonC	Cotton	2 Ground/ foliar	0	0.43	0.99	0.0049	15-Jun						
MethylParathion	MScottonC	Cotton	2 Aerial/ foliar	0	0.43	0.99	0.055	4-Jul	19	19				
Phorate + Degradates	MScottonC	Cotton	7 Ground/ plant	2.5	0.68	1	0.85	6-May						
Profenofos	MScottonC	Cotton	7 Ground/ plant	2.5	0.95	1	0.85	15-Jun						
Tribufos	MScottonC	Cotton	2 Air/ Harvest	0	0.75	0.99	0.055	2-Sep						
Disulfoton + Degradates	MScottonC	Cotton	2 Ground/ foliar	0	0.82	0.99	0.0049	23-May						
MethylParathion	MSsoybeanC	Soybean	2 Aerial/ foliar	0	0.51	0.99	0.055	31-Aug						
(1) Spray drift load estimated using Aq-Drift.														