Part II.

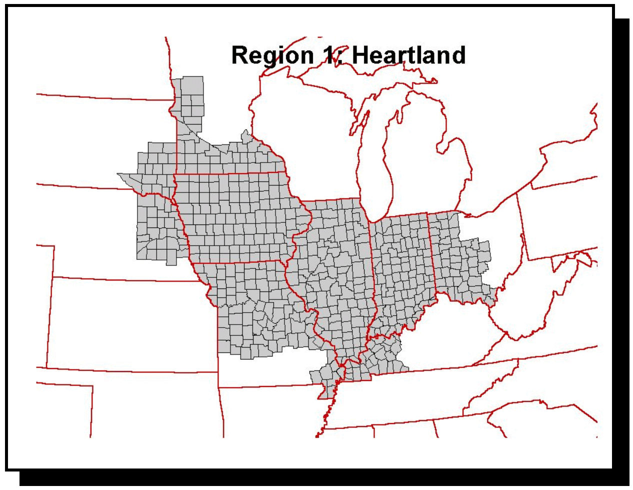
Preliminary Regional Risk Assessments

II. Preliminary Regional Risk Assessments

A. Region 1 - Heartland Assessment

1. Executive Summary

- This module of the Organophosphate (OP) cumulative risk assessment focuses on risks from OP uses in the Heartland (area shown to right). Information is included in this module only if it is specific to the Heartland, or is necessary for clarifying the results of the Heartland assessment. A comprehensive description of the OP cumulative assessment comprises the body of the main document; background and other supporting information for this regional assessment can be found there.



This module focuses on the two components of the OP cumulative assessment which are likely to have the greatest regional variability: drinking water and residential exposures. Dietary food exposure is likely to have significantly less regional variability, and is assumed to be nationally uniform. An extensive discussion of food exposure is included in the main document. Pesticides and uses which were considered in the drinking water and residential assessments are summarized in Table II.A.1 below. The OP uses included in the drinking water assessment generally accounted for 95% or more of the total OPs applied in that selected area. Various uses that account for a relatively low percent of the total amount applied in that area were not included in the assessment.

Table II.A.1. Pesticides and Use Sites/Scenarios Considered in Heartland Residential/Non-Occupational and Drinking Water Assessment

Pesticide	OP Residential Use Scenarios	OP Drinking Water Scenario Uses
Acephate	Ornamental Gardens	None
Bensulide	Golf Courses	None
Chlorethoxyphos	None	Corn
Chlorpyrifos	None	Corn
DDVP	Lawn applications, Indoor uses	None
Disulfoton	Ornamental Gardens	None

Pesticide	OP Residential Use Scenarios	OP Drinking Water Scenario Uses
Malathion	Lawn Applications, Home Fruit & Vegetable Gardens, Ornamental Gardens	None
Tebupirimphos	None	Corn
Terbufos	None	Corn
Trichlorfon	Golf Courses, Lawn applications	None

This module will first address residential exposures. The residential section describes the reasons for selecting or excluding various use scenarios from the assessment, followed by a description of region-specific inputs. Detailed information regarding the selection of generic data inputs common to all the residential assessments (e.g., contact rates, transfer coefficients, and breathing rate distributions, etc.) are included in the main document.

Drinking water exposures are discussed next. This will include criteria for the selection of a sub-region within the Heartland to model drinking water residues, followed by modeling results, and finally characterization of the available monitoring data which support use of the modeling results. This assessment accounted for all OP uses within the selected location that are anticipated to contribute significantly to drinking water exposure.

Finally a characterization of the overall risks for the Heartland region is presented, focusing on aspects which are specific to this region.

In general, the risks estimated for the Heartland show a similar pattern to those observed for other regions. Drinking water does not contribute to the risk picture in any significant way at the upper percentiles of exposure. At these higher percentiles of population exposure, residential exposures are the major source of risk - in particular inhalation exposure. These patterns occur for all population sub-groups, although potential risks appear to be higher for children than for adults regardless of the population percentile considered.

2. Development of Residential Exposure Aspects of Heartland Region

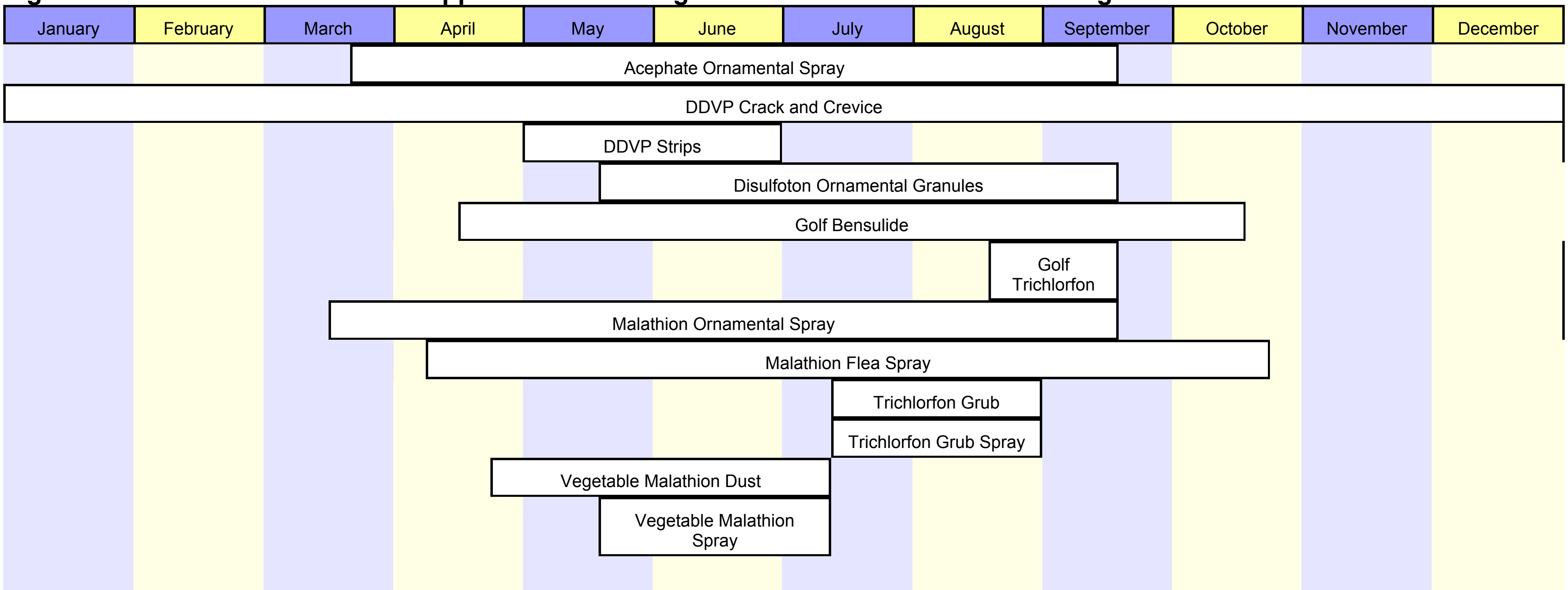
In developing this aspect of the assessment, the residential exposure component of Calendex was used to evaluate predicted exposures from residential uses. Except for golf course uses, this assessment is limited to the home as are most current single chemical assessments. The residential component of the assessment incorporates dermal, inhalation, and non-dietary ingestion exposure routes which result from applications made to residential lawns (dermal and non-dietary ingestion), golf courses, ornamental gardens, home fruit and vegetable gardens, and indoor uses. These scenarios were selected because they are expected to be the most prominent contributors to exposure in this region. Public health uses were not expected to be a significant contributor to cumulative risk in this region, and were therefore not included in this assessment. Additional details regarding the selection of the scenario-pesticide pairs can be found in Part I of this document. OPP believes that the majority of exposures (and all significant exposures) in this region have been addressed by the scenarios selected.

The data inputs to the residential exposure assessment come from a variety of sources including the published, peer reviewed literature and data submitted to the Agency to support registration and re-registration of pesticides. Generic scenario issues and data sources are discussed in Part I of this report. However, a variety of additional region-specific ancillary data was required for this assessment of the Heartland. This information includes region-specific data on pesticide application rates and timing, pesticide use practices, and seasonal applications patterns, among others. The Gaant chart shown in Figure II.A.1 displays and summarizes the various region-specific residential applications and their timing (including repeated applications) over the course of a year which were used in this assessment. Specific information and further details regarding these scenarios, the Calendex input parameters, and the pesticides for which these scenarios were used are presented in Table II.A.2 which summarizes all relevant region-specific scenarios.

Table II.A.2. Use Scenarios and Calendex Input Parameters for Heartland Residential Exposure Assessment

Chemical	Use Scenario and Pest	Appln. Method	Amount Applied lb ai/A	Maximum Number and Frequency of Applns.	Seasonal Use	% use LCO	% use HO	% users	Active Exposure Period (days)	Exposure Routes
Acephate	Ornamentals	hand pump sprayer	0.934-2	2/wk	March-Sept.	--	100	5	1	dermal, inhalation
Bensulide	Golf Courses	NA	12.5	2/yr	April-Oct.	100	--	3.05	14	dermal
DDVP	Crack/Crevice	spray can	0.72-2.5 mg	1/mth	Jan-Dec.	--	100	6	1	inhalation
	Pest Strips	strip	NA	2 spring 1 summer	May-June	N/.A	100	2.5	90	inhalation
Disulfoton	Ornamentals	granular	8.7	3/yr	May-Sept.	--	100	1.38	1	dermal, inhalation
Malathion	Lawns	hose end spray	5 lb ai	2/yr	April-Oct.	19	81	2	4 1	dermal, oral inhalation
	Ornamentals	hand pump spray	0.94-2 lb/A	4/yr	Mar-Sept.	--	100	3.7	1	dermal, inhalation
	Vegetable Gardens	hand duster	1.5 lb/A	5/yr	Apr-July	--	100	1.1	7 1	dermal, inhalation
		hand pump sprayer	1.5 lb/A	5/yr	May-July	--	100	1.1	7 1	dermal, inhalation
Trichlorfon	Golf Courses	NA	8 lb ai	1/yr	Aug-Sept.	100	--	3.05	1	dermal
	Lawns Granular	rotary spreader	8 lb ai	1/yr	July-Aug.	19	81	1	1 2	inhalation dermal, oral
	Lawns Spray	hose end sprayer	8 lb ai	1/yr	July-Aug.	19	81	1	1 2	inhalation dermal, oral

Figure II.A.1 Residential Scenario Application and Usage Schedules for the Heartland Region



a. Dissipation Data Sources and Assumptions

i. Bensulide

A residue dissipation study was conducted with multiple residue measurements collected for up to 14 days after treatment. For each day following application, a residue value from a uniform distribution bounded by the low and high measurements was selected (the day zero distribution consisted of measurements collected immediately after application and 0.42 day after treatment). No half-life value or other degradation parameter was used, with the current assessment based instead on the time-series distribution of actual measurements. Residues measured at day 7 were assumed to be available and to persist to day 10 and day 10 measurements to persist to day 14.

ii. Malathion

A residue degradation study was based on a 3-day study conducted on a cool-season grass in Missouri, North Carolina, and Pennsylvania (application rate 5 lb ai/acre). These measured residue values were entered into the Calendex software as a time series distribution of 4 values (Days 0, 1, 2, and 3). For use on home lawns for assessing non-dietary ingestion for children, these values were multiplied by a value selected from a uniform distribution bounded by 1.5 and 3 to account for wet hand transfer.

For vegetable gardening scenarios in eastern regions 1, 2, 3, 4, 5, 6, 9, and 12, data from a residue dissipation study conducted in Pennsylvania was used. Multiple residue measurements collected up to 7 days after treatment were made. A value selected from a uniform distribution bounded by the low and high measurements was used for each day after the application. Since the study was conducted at a one pound ai per acre treatment rate, the residues were adjusted upwards by a 1.5 factor to account for the 1.5 pound ai per acre rate for vegetables.

iii. Trichlorfon

Residue values from a residue degradation study for the granular and sprayable formulations were collected for the “day of” and “day following” the application. A uniform distribution bounded by the low and high residue measurements was used, with these residue values adjusted proportionately upwards to simulate the higher active ingredient concentrations in use (i.e., adjusted to 0.5% and 1% for granular and sprayable formulations respectively). These distributions reflect actual measurements including those based on directions to water in the product. For use on home lawns for assessing non-dietary ingestion for children, these values were multiplied by a value selected from a uniform distribution bounded by 1.5 and 3 to account for wet hand transfer.

3. Development of Water Exposure Aspects of Heartland Region

Because of the localized nature of drinking water exposure, the water exposure component of this assessment focused on a specific geographic area within the Heartland. The selection process considers OP usage, the locations and nature of the drinking water sources, and the vulnerability of those sources to pesticide contamination. An extensive discussion of the methods used to identify a specific location within the region is included in the main document. The following discussion provides the details specific to the Heartland regional assessment for drinking water exposure with respect to cumulative exposure to the OP pesticides. The discussion centers on four main aspects of the assessment: (1) the selection criteria for the specific location in central Illinois used for the drinking water assessment for the Heartland, (2) highlights of the results of the model outputs (predicted cumulative concentrations of OPs in surface water) for those OP-crop uses included in this regional assessment, (3) a summary and comparison of the predicted concentrations used in the Heartland assessment with actual surface water monitoring data for the region, and (4) a summary of water monitoring data used for site selection and evaluation of the estimated drinking water concentrations for the region.

a. Selection of eastern Illinois for Drinking Water Assessment

OPP selected the area around Livingston, Champaign, Tazewell, Logan, Ford, and Woodford counties in central Illinois as the specific location to represent the region based on organophosphorus (OP) pesticide usage within the Heartland region (the region) in relation to the source, location, and vulnerability of the drinking water sources in the region, and on available monitoring data for the region. An evaluation of OP usage, drinking water sources, vulnerability of those sources to OP pesticide contamination, and available monitoring data indicates that (1) surface water sources of drinking water are likely to be more vulnerable than ground water sources, and (2) a surface water assessment based in eastern Illinois will represent one of the more vulnerable sources of drinking water in the region.

Total OP usage is relatively high in the Heartland, accounting for approximately 14% of total OP use in the U.S. The major OP use crop in the Heartland is corn (93% of total OP use in the entire region). Alfalfa (3%), orchards (1%), and vegetables, primarily legumes (<1%), account for small portions of OP use in the region (Table II.A.3). In 1997, approximately 7.6 million pounds (ai) of OPs were applied in on agricultural crops in this region.

Table II.A.3. General Overview of OP Usage in the Heartland

Crops	Primary Production Areas	Total Pounds Applied	Percent of Total OP Use
Corn	Throughout Region	7,098,000	93%
Alfalfa	Scattered	216,000	3%
Orchard (Apples, peaches)	Scattered	84,000	1%
Vegetables (legumes)	Scattered	32,000	0.5%
Total		7.6 Million	97.5%

(1) Source: NCFAP, 1997.

Figure II.A.2 shows a high OP-use band that runs from northeastern Nebraska eastward through northern Iowa and central Illinois and Iowa. OPP focused on the central Illinois use area for its drinking water assessment because of the overlap between high OP usage and vulnerability of surface water sources of drinking water.

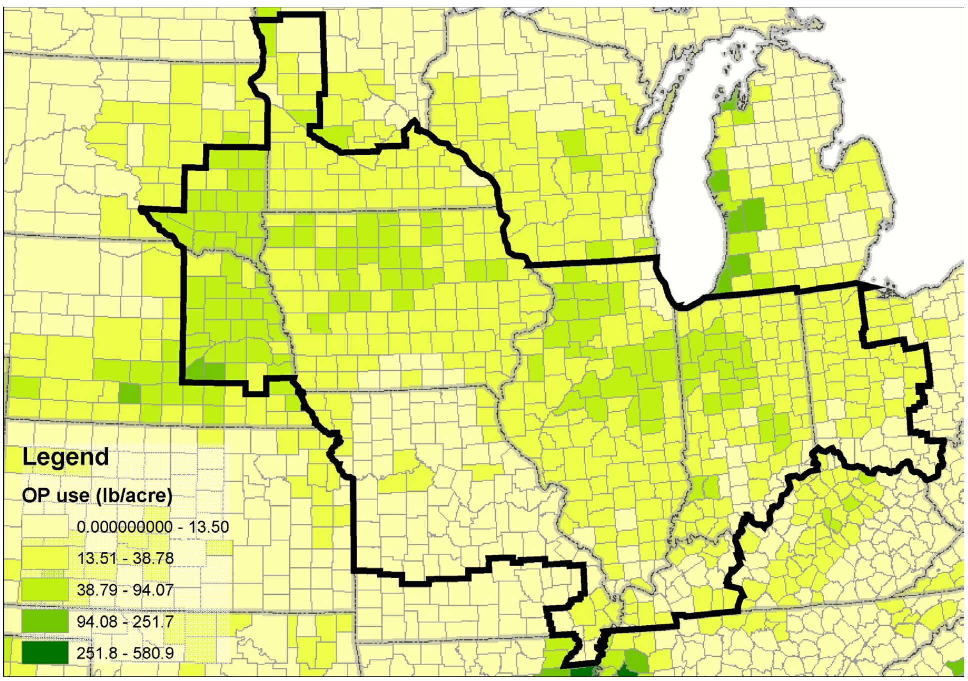


Figure II.A.2. Total OP usage (pounds per area) in the Heartland (source: NCFAP, 1997)

In central Illinois (focusing around Livingston, Champaign, Tazewell, Logan, Ford, and Woodford counties), OP use on corn alone accounted for greater than 96% of total agricultural use. No other crop use accounted for more than 0.5% of OP usage. The latest NASS usage data found that four OP pesticides were used on corn in these counties (Table II.A.4). As discussed below, these four uses were used to develop the drinking water assessment for this region.

Table II.A.4. OP Usage on Agricultural Crops in Central Illinois (Livingston, Champaign, Tazewell, Logan, Ford, and Woodford Counties)

OP Usage/ Agricultural Crops				Cropland Acreage, Central IL Assessment Area	
Crop Group	**Crops**	**OP Usage**	**Percent of Total OP Use**	**Acres**	**Pct of total Cropland**
Corn	Corn, Sweet Corn	chlorpyrifos, terbufos, chlorethoyxfos, phostebupirim	96%	1,509,000	50%
Total			96%	1,509,000	50%

Pesticide use based latest data collected by USDA National Agricultural Statistics Service (NASS). Acreage estimates based on IL Agricultural Statistics Service. Details on the sources of usage information are found in Appendix III.E.8.

Both surface water and ground water are important sources of drinking water in the Heartland. Surface-water sources are scattered throughout the region, with a higher intensity of intakes in a belt running from southern Iowa/northern Missouri through south and central Illinois and southern Indiana into Ohio. In general, the vulnerability of the surface water sources of drinking water to pesticide runoff increases from north to south within the region, with the highest runoff intensities occurring in Missouri and central/southern Illinois (Figure II.A.3).

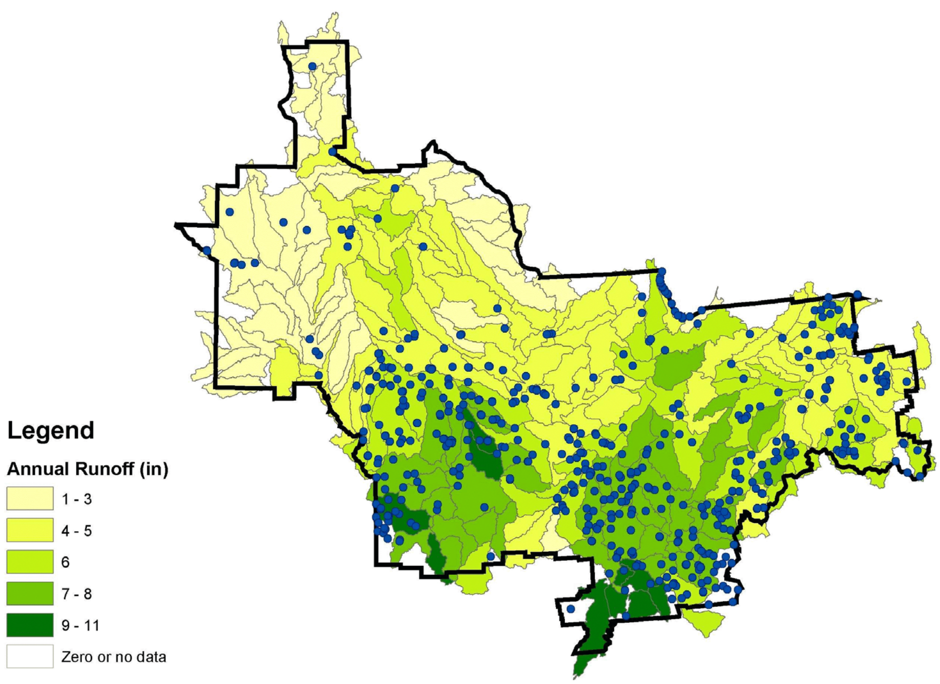


Figure II.A.3. Locations of surface water intakes of drinking water (shown as dots) in relation to average annual runoff (color gradation) in the Heartland Region

The overlying soils, geology, and rainfall make the ground water in the eastern two-thirds of the Heartland more vulnerable to pesticide leaching than the western third. The most vulnerable areas to pesticide leaching occur in north/central Illinois, northern Indiana, eastern Nebraska, and the southern portion of the region extending into Kentucky (Figure II.A.4). Surficial glacial outwash deposits supply more than 50% of ground water withdrawn in Illinois, Indiana and Ohio (USGS Water Atlas HA-730-K). Outwash deposits form important aquifers where they are comprised of coarse sand and gravel. In some locations these deposits are present at the surface as water-table aquifers. In other areas they are present as lenses buried by thick deposits of finer silts and clays. These confined aquifers are less susceptible to contamination by human activities.

Aquifers in deeper, older sedimentary rocks also provide drinking water to a significant portion of the population of the Heartland. Bedrock aquifers are confined throughout most of the Heartland region, with important exceptions like the Iowan karst. Pesticide contamination will be very unlikely in water drawn from this aquifer where it is confined. Where the confining unit has been removed by erosion, the upper part of the aquifer system is in direct contact with the overlying surficial aquifer system in north-central Illinois and southeastern Wisconsin. Where the two systems are in contact, ground-water pumping has induced greater recharge from the shallower system.

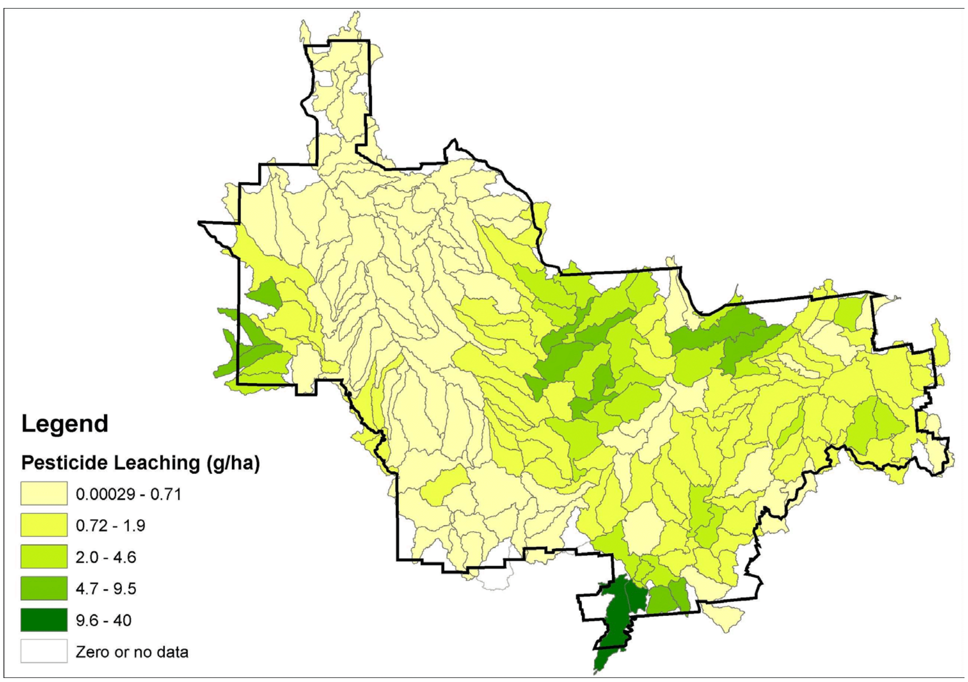


Figure II.A.4. Vulnerability of ground water resources to pesticide leaching in the Heartland, adapted from USDA (Kellogg, 1998)

An evaluation of OP usage, drinking water sources, vulnerability of those sources to OP pesticide contamination, and available monitoring data indicates that (1) surface water sources of drinking water are likely to be more vulnerable than ground water sources, and (2) a surface water assessment based in central Illinois is representative of the more vulnerable areas within the Heartland region. However, even in a region such as this, where surface water is an important source of public supply, a significant portion of the population derives its drinking water from the surficial glacial till aquifers. The central Illinois counties are located within the Lower Illinois River Basin. While 52% of public supplies are derived from surface water, all domestic water supply is from ground water. The USGS indicated that "rural" residents (about 25% of the population) rely on private wells for drinking water. However, since the OPs used in the Heartland region were rarely detected in ground water, and because much of the ground-water supply is in deep, confined aquifers, the surface-water exposure assessment should be considered a conservative surrogate for the portion of the population deriving its drinking water from ground water.

b. Cumulative OP Concentration Distribution in Surface Water

The Agency estimated drinking water concentrations in the Heartland cumulative assessment using PRZM-EXAMS output with various input parameters that are specific, where possible, to central Illinois. Table II.E.5 presents pesticide use statistics for the four chemicals used on corn which were modeled in this regional assessment. Chemical-, application- and site-specific inputs into the assessments are found in Appendices III.E.5-7. Sources of usage information can be found in Appendix III.E.8. Based on the latest available USDA National Agricultural Statistics Service (NASS) usage data, these uses represent roughly 96% of agricultural use of OP pesticides in central Illinois.

Table II.A.5. OP-Crop Combinations Included in the Heartland Assessment, With Application Information Used in the Assessment

Chemical	Crop/Use	Pct. Acres Treated	App. Rate, lb ai/A	App Meth/ Timing	Application Date(s)	Range in Dates (most active dates)
Chlorpyrifos	Corn	13%	1.2	Ground, at planting	9-May	Apr22-May28 (Apr30-May18)
Terbufos	Corn	4%	1.24	Ground, at planting	9-May	Apr22-May28 (Apr30-May18)
Chlorethoxyfos	Corn	4%	0.08	Ground, at planting	9-May	Apr22-May28 (Apr30-May18)
Phostebupirim (tebupirimphos)	Corn	3%	0.1	Ground, at planting	9-May	Apr22-May28 (Apr30-May18)
Cumulative OP PCA for the region: 0.46 [NOTE: This is the corn PCA for the region] Weather data used to simulate rainfall (meterological file): Met111.met (Vandalia, OH)						

Figure II.E.5 displays 35 years of predicted OP cumulative concentrations for the Heartland drinking water assessment. This chart depicts a single peak occurring each year, with some years having higher levels than others. These variations are the result of year-to-year differences in precipitation from the weather data for the region. The OP cumulative concentration levels are generally low, not exceeding 1 ppb in methamidophos equivalents.

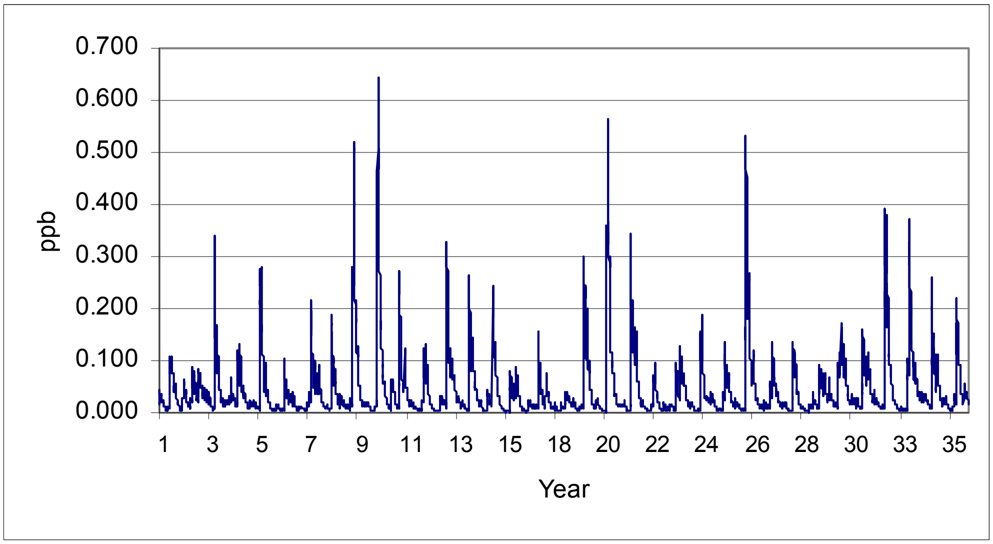


Figure II.A.5. Cumulative OP Distribution in Water in the Heartland (Methamidophos equivalents).

Figure II.E.6 overlays all 35 years of predicted values over the Julian calendar. Here, for example, each of the 35 yearly values associated with February 1st (i.e., Julian Day 32) are graphed such that the spread of concentration associated with February 1st (over all years) can readily be seen. This chart indicates that OP concentrations follow a recurring pattern each year, with a peak occurring about day 150.

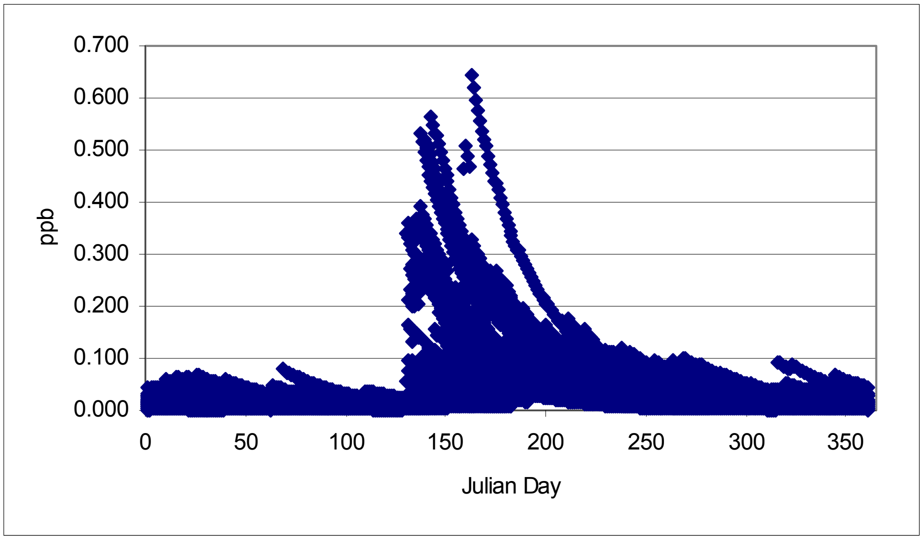


Figure II.A.6. Cumulative OP Distribution in Water (Methamidophos Equivalents) in the Heartland, summarized on a daily basis over 35 years

Figure II.E.7 depicts the predicted OP cumulative concentration for uses that made significant contributions during Year 10, the year in which the highest modeled concentration occurred. Phostebupirim and terbufos use on corn were the two uses primarily contributing to the peak (0.6 ppb - methamidophos equivalent) that was predicted in early June (~week 23). Both of these OPs (as well as chlorpyrifos and chlorethoxyfos) were applied to corn on May 9th (week 19). It is important to note that these concentrations are converted to methamidophos equivalents based on relative potency factors. Thus, the relative contributions are the result of both individual chemical concentrations in water and the relative potency factor of each of the OP chemicals found in the water. In the case of phostebupirim, a surrogate relative potency factor that was roughly three orders of magnitude greater than that for terbufos or chlorpyrifos, greatly impacted its relative contribution to the cumulative OP load.

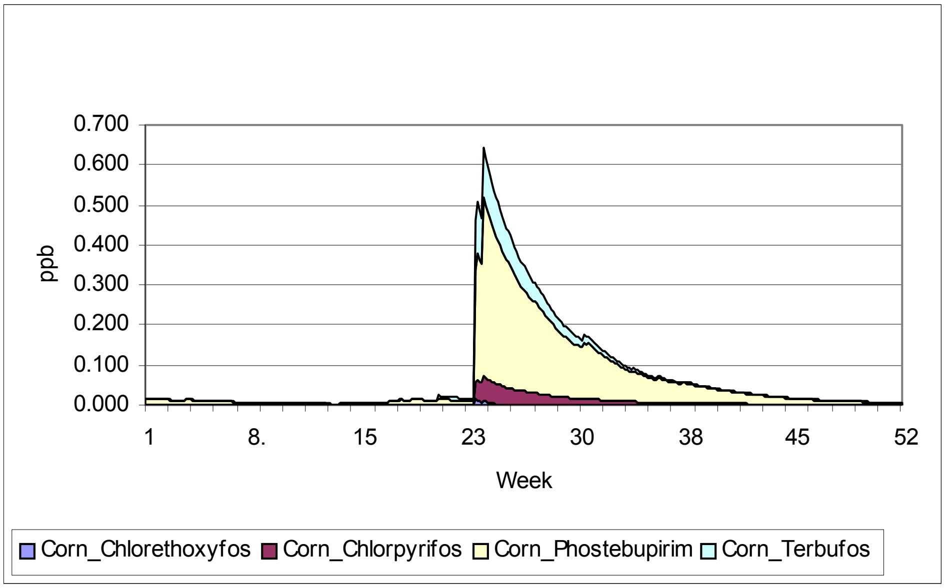


Figure II.A.7. Cumulative OP Distribution for an Example Year (Year 10) in the Heartland Region Showing Relative Contributions of the Individual OPs in Methamidophos Equivalents

c. A Comparison of Monitoring Data versus Modeling Results

A comparison of estimated concentrations for individual OP pesticides (Table II.E.6) with NAWQA monitoring (summarized below and in Appendix III.E.1) indicate that the predicted concentrations of OPs in surface water in central Illinois correlate reasonably well with available monitoring data for the region. Although the estimated cumulative OP concentrations used in the exposure assessment represent concentrations that would occur in a reservoir, and not in the streams and rivers represented by the NAWQA sampling, a comparison of the PRZM/EXAMS OP concentrations with NAWQA data show good correlation even if the data sets don't represent identical surface water sources.

Table II.A.6. Percentile Concentrations of Individual OP Pesticides and of the Cumulative OP Distribution, 35 Years of Weather

Chemical	Crop/Use	Concentration, ug/L						
		Max	99th	95th	90th	80th	75th	50th
Chlorethoxyfos	Corn	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Chlorpyrifos	Corn	0.629	0.314	0.172	0.117	0.063	0.048	0.013
Phostebupirim	Corn	0.018	0.007	0.004	0.003	0.002	0.002	0.001
Terbufos	Corn	0.302	0.138	0.048	0.023	0.006	0.003	0.000
OP Cumulative Concentrations (in Methamidophos equivalents, ppb)		0.643	0.308	0.153	0.101	0.063	0.050	0.020

The estimated peak and upper percentile concentrations of chlorpyrifos are roughly equivalent to the concentrations detected in the agricultural watersheds of the Lower Illinois River Basin (LIRB). 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 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; however, these estimates include parent terbufos plus the sulfoxide and sulfone transformation products while NAWQA only analyzed for the less persistent and less mobile parent.

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.

d. Summary of Available Monitoring Data for the Heartland

Monitoring data from the USGS NAWQA program and individual State Agencies within the Heartland show that surface-water and ground-water contamination with OP insecticides are reported much less frequently than contamination with herbicides in the Heartland (and nationwide). This is due in great part to the difference in the persistence and mobility of the OPs from the most commonly detected herbicides. However, this is also an artifact of the extent of sampling for OPs. Because the herbicides are such common contaminants of surface water and ground water, States have concentrated limited resources on the study of herbicide contamination of water resources.

By the same token, evaluation of surface-water and ground-water contamination by OPs has concentrated mainly on those OPs which were detected most in previous studies, namely chlorpyrifos, diazinon, and malathion. These insecticides were also the most frequently detected of the nine active OPs included in the NAWQA studies for which data are currently available. Many of the detections of chlorpyrifos and diazinon appear to be from non-agricultural sources which are currently being phased out. However, there are still many reported agricultural stream detections of diazinon, which is not an important corn insecticide. Detections of diazinon in agricultural streams in the Heartland regions may reflect rural or small town residential use of the compound.

A number of monitoring studies have been performed in the Heartland region and reflect pesticide concentrations in both surface water and ground water. The most commonly detected OP pesticides in these studies were diazinon, chlorpyrifos, malathion, and fonofos. The highest detections and frequency of detections for both diazinon and malathion occurred in urban/residential watersheds. Chlorpyrifos was detected at higher concentrations and more frequently in agricultural watersheds in Illinois and in urban/residential watersheds in Indiana. All fonofos uses and the residential uses of chlorpyrifos and diazinon are being phased out and, thus, are not included in the cumulative water exposure assessment. While the water exposure assessment did not account for residential contributions of malathion in the cumulative load, malathion has a small relative potency factor (0.0003) and the resultant contribution of residential sources of malathion is not expected to contribute significantly to the overall drinking water exposure.

The White River Basin (IN) tended to have the greatest frequency of detections and the Eastern Iowa Basins the lowest frequency. The high frequency of detections in the White River Basin was influenced by the urban/residential uses of OP pesticides in that basin – in particular, chlorpyrifos, diazinon, and malathion. The Lower Illinois River Basin had the highest detects and greatest frequency of detections for chlorpyrifos and terbufos in agricultural-dominated watersheds. Neither chlorethoxyfos nor phostebupirim were included in the NAWQA study.

The **NAWQA Lower Illinois River Basin (LIRB) study** unit includes the high OP-use counties of central Illinois which serve as the location for the regional drinking water assessment. The study area is located central Illinois, and is an area of intense corn and soybean row-crop agriculture. Sampling in this study occurred between 1995 and 1998. Surface-water sampling was conducted in “two watersheds with greater than 90 percent row-crop agriculture and the basin inflow and outflow sites (Circular1209).”

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 was detected at concentrations of 0.013 and 0.016 ug/l.

While the White River is an important source of drinking water, 55% of people in the White River Basin rely on ground water for their drinking water. About half of the population deriving drinking water from ground water do so from private domestic wells. Ground-water samples were taken once from 94 wells (both from confined aquifers and unconfined glacial outwash aquifers) in both urban and agricultural areas. Forty-nine of these outwash wells, and nine deeper outwash wells, were sampled to further assess the water-quality of this aquifer. In addition, a small number of wells, lysimeters and tile drains were sampled in a flow-path study. OPs were not detected in ground water in the WHIT study unit.

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 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.

Ground water is the major source of fresh water supply in the study unit. Ground-water studies included 124 wells (half domestic wells, half monitoring wells) that drew from the surficial alluvial aquifers, and the older bedrock aquifers. The bedrock aquifers sampled were mostly deep, and somewhat protected from surface contamination by surficial materials. However, samples were also taken from the Iowan karst, which is covered by little or no overburden, and is particularly vulnerable to contamination due to solution porosity. 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.

Only a few states in the Heartland region have included OP pesticides in their monitoring programs (see Appendix III.E.3 for details on the state monitoring programs). In the first three years of **Indiana**'s "Surface Water Quality Assessment Program," only one OP, tetrachlorvinphos, was detected in the three years of sampling. In **Iowa**, chlorpyrifos, ethoprop, fonofos, phorate, terbufos, dimethoate, diazinon, malathion, and parathion were included in the Statewide Rural Well-Water Study. 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. In Iowa's Ambient Surface Water Monitoring program, only one detection of parathion and two detections of chlorpyrifos have occurred since 1999. Concentrations detected were low, in the 0.05 ppb range. **Nebraska**'s "Quality-Assessed Agricultural Contaminant Database for

Nebraska Ground Water," has no reported detections for chlorpyrifos, diazinon, disulfoton, ethion, malathion, methyl parathion, phorate, or terbufos. The levels of detection are generally below 1 ppb.

4. Results of Cumulative Assessment

Analyses and interpretation of the outputs of a cumulative distribution rely heavily upon examination of the results for changing patterns of exposure. To this end, graphical presentation of the data provides a useful method of examining the outputs for patterns and was selected here to be the most appropriate means of presenting the results of this cumulative assessment. Briefly, the cumulative assessment generates multiple potential exposures for each hypothetical individual in the assessment for each of the 365 days in a year. Because multiple calculations for each individual in the CSFII population panel are conducted for each day of the year, a distribution of daily exposures is available for each route and source of exposure throughout the entire year. Each of these generated exposures is internally consistent – that is, each generated exposure appropriately considers temporal, spatial, and demographic factors such that "mismatching" (such as combining a winter drinking water exposure with an exposure that would occur through a spring lawn application) is precluded. In addition, a simultaneous calculation of MOEs for the combined risk from all routes is performed, permitting the estimation of distributions of the various percentiles of total risk across the year. As demonstrated in the graphical presentations of analytical outputs for this section, results are displayed as MOEs with the various pathways, routes, and the total exposures arrayed across the year as a time series (or time profile). Any given percentile of these (daily) exposures can be selected and plotted as a function of time. That is, for example, a 365-day series of 95^{th} percentile values can be plotted, with 95^{th} percentile exposures for each day of the year (January 1, January 2, etc) shown. The result can be regarded as a "time-based exposure profile plot" in which periods of higher exposures (evidenced by low 'Margins of Exposure') and lower exposures (evidenced by high 'Margins of Exposure') can be discerned. Patterns can be observed and interpreted and exposures by different routes and pathways (e.g., dermal route through lawn application) seen and compared. Abrupt changes in the slope or level of such a profile may indicate some combination of exposure conditions resulting in an altered risk profile due to a variety of factors. Factors may include increased pest pressure and subsequent home pesticide use, or increased use in an agricultural setting that may result in increased concentrations in water. Alternatively, a relatively stable exposure profile indicates that exposure from a given source or combination of sources is stable across time and the sources of risk may be less obvious. Different percentiles can be compared to ascertain which routes or pathways tend to be more significant contributors to total exposure for different subgroups of the Heartland population (e.g, those at the 95^{th} percentile vs. 99^{th} percentiles of exposure).

Figures III.I.2-1 through III.I.2-5 in Appendix I present the results of this cumulative risk analysis for Children, 1-2 years for a variety of percentiles of the Heartland population (95^{th}, 97.5^{th}, 99^{th}, 99.5^{th}, and 99.9^{th}). Figures III.I.2-6 through III.I.2-10, Figures III.I.2-11 through III.I.2-15, and Figures III.I.2-16 through III.I.2-20 present these same figures for Children 3-5, Adults 20-49, and Adults 50+, respectively. The following paragraphs describe, in additional detail, the exposure profiles for each of these population age groups for these percentiles (i.e., 95^{th}, 97.5^{th}, 99^{th}, 99.5^{th}, and 99.9^{th}). Briefly, these figures present a series of time course of exposure (expressed as MOEs) for various age groups at various percentiles of exposure for the population comprising that age group. For example, for the 95^{th} percentile graphs, the 95^{th} percentile (total) exposure is estimated for each of the 365 days of the year, with each of these (total) exposures – expressed in terms of MOE's – plotted as a function of time. The result is a "time course" (or "profile") of exposures representing that portion of the Heartland population at the 95^{th} percentile exposures throughout the year. Each "component" of this 95^{th} percentile total exposure (i.e., the dermal, inhalation, non-dietary oral, food, and water, etc. "component" exposures which, together, make up the total exposure) can also be seen – each as its own individual time profile plot. This discussion represents the unmitigated exposures (i.e., exposures which have not been attempted to be reduced by discontinuing specific uses of pesticides) and no attempt is made in this assessment to evaluate potential mitigation options. The following paragraphs describe the findings and conclusions from each of the assessments performed.

a. Children 1-2 years old

(Figures III.I.2-1 through III.I.2-5): At the 95th percentile, exposures from the residential applications of OP pesticides do not appear in the overall exposure to the pesticides in this region. This is true for all of the routes of exposure examined: dermal and hand-to-mouth exposure from lawn treatment applications and inhalation exposure from indoor crack and crevice and pest strip treatments. Despite increases in drinking water concentrations during Julian days 130 to 190 which corresponds to applications of phostebupirim and terbuphos to corn during the first week in May, drinking water at this percentile also does not contribute to substantial exposure. At the higher percentiles the exposure profile and relative contributions begin to change. The residential exposures (inhalation component) become an increasingly dominant portion of the total exposure profile. This corresponds to use of DDVP (pest strips and crack and crevice sprays). While these residential exposures via the inhalation pathway from the use of these DDVP products first appear at the 97.5th percentile, it is not until the 99.9th percentile that they become the most significant contributors to overall risk throughout the year. This is not true for drinking water exposures which continue to be low and do not contribute in any significant manner to the overall risk picture. By the 99th percentile, dermal and/or hand-to-mouth exposures from lawn uses begin to appear but remain low and continue to be a small fraction of total exposure (<10%) throughout all percentiles examined.

b. Children 3-5 years old

(Figures III.I.2-6 through III.I.2-10): As with Children 1-2, exposures from the residential applications of OP pesticides do not appear in the overall exposure to the pesticides in this region at the 95th percentile. This is true for all of the routes of exposure examined: dermal and hand-to-mouth exposure from lawn treatment applications and inhalation exposure from indoor crack and crevice and pest strip treatments. Despite increases in drinking water concentrations during Julian days 130 to 190 which corresponds to applications of phostebupirim and terbuphos to corn during the first week in May, drinking water at this percentile also does not contribute to substantial exposure. At the higher percentiles the exposure profile and relative contributions begin to change. The residential exposures become an increasingly dominant portion of the total exposure profile. This corresponds to use of DDVP (pest strips and crack and crevice sprays). While these residential exposures via the inhalation pathway from the use of these DDVP products first appear at the 97.5th percentile, it is not until the 99.9th percentile that they are significant contributors to overall risk throughout the year. This is not true for drinking water exposures which continue to be low and do not contribute in any significant manner to the overall risk picture. By the 99.5th percentile, dermal and/or hand-to-mouth exposures from lawn uses begin to appear in the overall risk picture but remain comparatively low and continue to be a small fraction of total exposure (<10%) throughout all percentiles examined.

c. Adults, 20-49 and Adults 50+ years old

(Figures III.I.2-11 through III.I.2-15 and III.I.2-16 through III.I.2-20): At the 95th percentile, exposures from the residential applications of OP pesticides are not contributors to the overall exposure to the pesticides in this region. This is true for all of the routes of exposure examined: dermal exposure from lawn and garden and golf course treatment applications and inhalation exposure from lawn and gardening activities and indoor crack and crevice and pest strip treatments. Despite increases in drinking water concentrations during Julian days 130 to 190 which corresponds to applications of phostebupirim and terbuphos to corn during the first week in May, drinking water at this percentile also does not contribute to substantial exposure. At the higher percentiles the exposure profile and relative contributions begin to change. The residential exposures become an increasingly dominant portion of the total exposure profile. This corresponds to use of DDVP (pest strips and crack and crevice treatments). At the 97.5th percentile and above, residential exposures via inhalation pathway from the use of these DDVP products begin to contribute to overall exposure. By the 99.9th percentile, these DDVP exposures are the most significant contributors to the overall risk picture. Drinking water exposures, continue to be low and do not contribute in any significant manner to overall risk. By the 99th percentile, dermal exposures begin to appear but remain comparatively low and continue to be a small fraction (< ca. 1%) of total exposure throughout all percentiles examined.