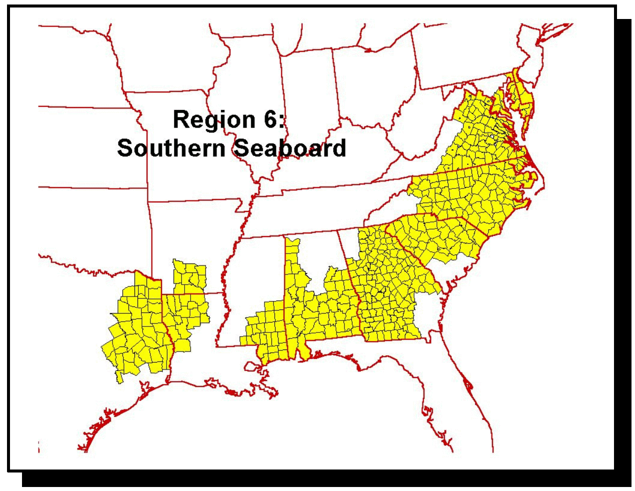
II. Regional Assessments

F. Region 6 - Southern Seaboard Assessment

1. Executive Summary

This module of the Organophosphate (OP) cumulative risk assessment focuses on risks from OP uses in the Southern Seaboard (area shown to right). Information is included in this module only if it is specific to the Southern Seaboard, or is necessary for clarifying the results of the Southern Seaboard 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 exposures 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.F.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.F.1. Pesticides and Use Sites/Scenarios Considered in Southern Seaboard Residential/Non-Occupational and Drinking Water Assessment

Pesticide	OP Residential Use Scenarios	OP Drinking Water Scenario Uses
Acephate	Golf Courses, Ornamental Gardens	Peanuts, Cotton, Tobacco
Bensulide	Golf Courses	None
Chlorpyrifos	None	Corn, Peanuts, Tobacco
DDVP	Indoor Uses	None

Pesticide	OP Residential Use Scenarios	OP Drinking Water Scenario Uses
Dimethoate	None	Cotton
Disulfoton	Ornamental Gardens	Cotton
Ethoprop	None	Tobacco
Fenamiphos	Golf Courses	Tobacco
Malathion	Lawn Applications, Home Fruit & Vegetable Gardens, Ornamental Gardens, Public Health	None
Phorate	None	Cotton, Peanuts
Terbufos	None	Corn
Tribufos	None	Cotton
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 Southern Seaboard 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 Southern Seaboard region is presented, focusing on aspects which are specific to this region.

In general, the risks estimated for the Southern Seaboard 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 Southern Seaboard Region 6

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, public health uses, and indoor uses. These scenarios were selected because they are expected to be the most prominent contributors to exposure in this region. 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.

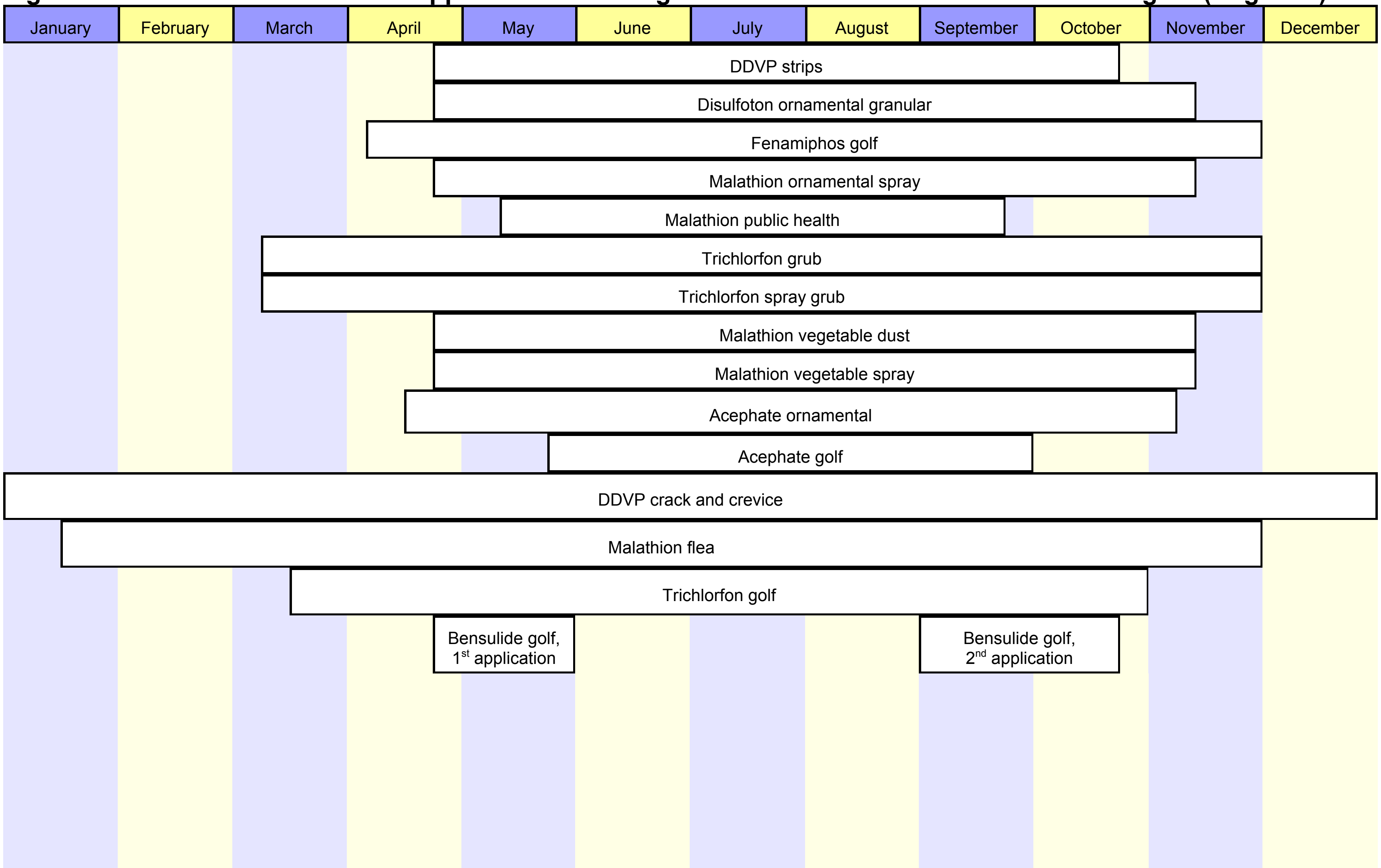
The data inputs to the residential exposure assessment come from a variety of sources including the published, peer reviewed literature and data submitted to the Agency to support registration and re-registration of pesticides. Generic scenario issues and data sources are discussed in Part I of this report. However, a variety of additional region-specific ancillary data was required for this assessment of the Southern Seaboard. 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.F.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.F.2 which summarizes all relevant region-specific scenarios.

Table II.F.2. Use Scenarios and Calendex Input Parameters for Southern Seaboard 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	Golf Courses	NA	5	1/yr	May-Oct.	100	--	1.22	10	dermal
	Ornamentals	hand pump sprayer	0.934-2	4/yr	April-Nov.	--	100	6	1	dermal, inhalation
Bensulide	Golf Courses	NA	12.5	2/yr	April-May Sept-Oct.	100	--	4.27	14	dermal
DDVP	Crack/Crevice	spray can	0.72-2.5 mg	1/mth	Jan-Dec.	--	100	8	42	inhalation
	Pest Strips	strip	NA	3/yr	April-Aug. Aug-Oct.	NA	100	2.5	90	inhalation
Disulfoton	Ornamentals	granular	8.7	3/yr	April-Nov.	--	100	2	1	dermal, inhalation
Fenamiphos	Golf Courses	NA	116	1/yr	April-Dec.	100	--	1	1	dermal
Malathion	Lawns	hose end spray	5 lb ai	2/yr	Jan-Dec.	8	92	1.54	4 1	dermal, oral inhalation
	Ornamentals	hand pump spray	0.94-2 lb/A	4/yr	April-Nov.	--	100	3.7	1	dermal, inhalation
	Public Health Mosquitoes	aerial & ground	NA	9/yr	May-Sept.	100	--	55.4	2	dermal, oral
	Vegetable Gardens	hand duster	1.5 lb/A	5/yr	April-Nov.	--	100	1.1	14 1	dermal, inhalation
		hand pump sprayer	1.5 lb/A	5/yr	April-Nov.	--	100	1.1	7 1	dermal inhalation

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
Trichlorfon	Golf Courses	NA	8 lb ai	1/yr	March-Nov.	100	--	1.22	1	dermal
	Lawns Granular	rotary spreader	8 lb ai	1/yr	March-Dec.	8	92	1	1 2	inhalation dermal, oral
	Lawns Spray	hose end sprayer	8 lb ai	1/yr	March-Dec.	8	92	1	1 2	inhalation dermal, oral

Figure II.F.1 Residential Scenario Application and Usage Schedules for Southern Seaboard Region (Region 6)



a. Dissipation Data Sources and Assumptions

i. Acephate

A residue dissipation study was conducted on Bahia grass in Florida with multiple residue measurements collected for 10 days after treatment (Days 0, 1, 2, 3, 5, 7, and 10 days). No half-life value or other degradation parameter was used, with the current assessment based instead on the time-series distribution of actual residue measurements.

ii. 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.

iii. 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 of 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 vegetables in eastern regions 1,2,3,4,5,6,9, and 12, data from a residue dissipation study conducted in Pennsylvania was used in which multiple residue measurements collected up to 7 days after treatment were available. A residue value selected from a uniform distribution bounded by the high and low residue measurements was used for each day after the application. The study was conducted a one pound ai per acre. The residues were adjusted upwards to account for the 1.5 pound ai per acre rate for vegetables.

iv. Trichlorfon

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

3. Development of Water Exposure Aspects of Southern Seaboard 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 Southern Seaboard. 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 Southern Seaboard 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 eastern North Carolina used for the drinking water assessment for the Southern Seaboard, (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 Southern Seaboard 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 North Carolina for Drinking Water Assessment

OPP selected the area around Pitt, Martin, Edgecombe, Greene, and Lenoir counties in eastern North Carolina as the specific location to represent the region based on organophosphorus (OP) pesticide usage within the Southern Seaboard 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 North Carolina will represent one of the more vulnerable sources of drinking water in the region.

Total OP usage is relatively high in the region, where, in 1997, approximately 7 million pounds (ai) of OPs were applied in on agricultural crops. Cotton (33% of total OP use in the region), tobacco (17%), corn (16%), peanuts (15%), and alfalfa (9%) accounted for nearly 90% of OP usage in the Southern Seaboard (Table II.F.3). Other OP-use crops in the region include orchards (peaches and apples) and pecans.

Table II.F.3. General Overview of OP Usage in the Southern Seaboard

Crops	Primary Production Areas	Total Pounds Applied	Percent of Total OP Use
Cotton	Throughout the coastal plain	2,300,000	33
Tobacco	NC and SC coastal plain	1,210,000	17
Corn	Throughout the region, with the highest acreage in the NC and SC coastal plain	1,100,000	16
Peanuts	GA Coastal Plain	1,027,000	15
Alfalfa	Throughout the region	657,000	9
Orchard	Peaches in GA coastal plain; apples in NC Piedmont	181,000	3
Pecans	Primarily in GA; some extending north to NC	221,000	3
		7,000,000	96

Source: NCFAP, 1997.

OP use in the Southern Seaboard is concentrated in the coastal plain, with the highest intensities of use in eastern North Carolina and southern Georgia (Figure II.F.2). OP use on cotton and corn occur throughout the coastal plain. Use on tobacco is primarily focused in the North Carolina and South Carolina portion of the coastal plain. Use on peanuts, peaches, and pecans is concentrated in the Georgia portion of the coastal plain. As described below, OPP focused on the North Carolina portion of the coastal plain for its drinking water assessment because of the overlap between high OP usage and vulnerability of surface water sources of drinking water.

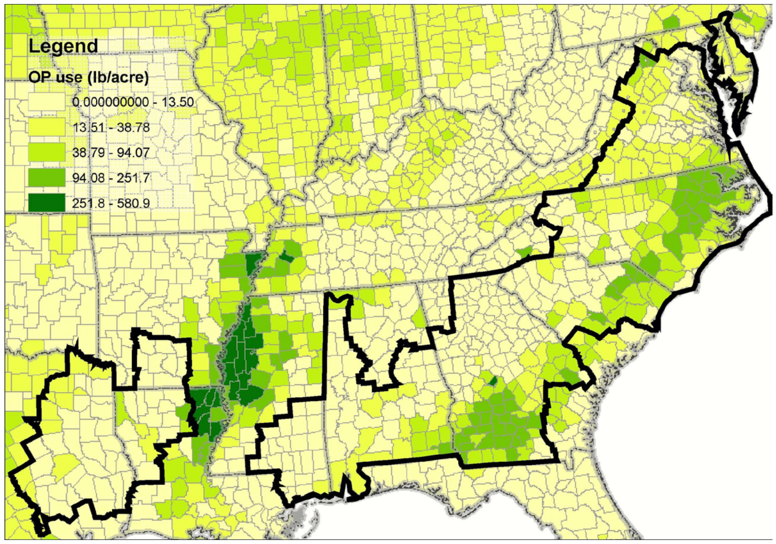


Figure II.F.2. Total OP usage (pounds per area) in the Southern Seaboard (source: NCFAP, 1997)

In eastern North Carolina (focusing around Pitt, Martin, Edgecombe, Greene, and Lenoir counties), OP use on cotton, tobacco, and corn accounted for 93 percent of total agricultural use (Table II.F.4). The latest NASS usage data found that 14 OP-crop combinations accounted for approximately 87 percent of agricultural OP usage in these counties. As discussed below, these uses were used to develop the drinking water assessment for this region.

Table II.F.4. OP Usage on Agricultural Crops in Eastern North Carolina (Pitt, Martin, Edgecombe, Greene, and Lenoir Counties)

OP Usage/ Agricultural Crops				Cropland Acreage, Assessment Area	
Crop Group	**Crops**	**OP Usage**	**Percent of Total OP Use**	**Acres**	**Pct of total Cropland**
Cotton	Cotton	70,000	43	209,000	39
Corn	Corn	33,000	20	63,000	12
Tobacco	Tobacco	50,000	30	27,000	5
Peanuts	Peanuts	11,000	7	30,000	6
				328,000	62

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

Surface water sources of drinking water are common in the western portion of the region, in the Piedmont region (Figure II.F.3). The Piedmont is characterized by older bedrock which forms a more varied topography. The Piedmont region includes both agricultural regions and highly developed land, and surface-water bodies are important sources of drinking water. Overlap of surface water intakes with the high OP use areas of the coastal plain is largely confined to North Carolina and South Carolina. Although the database for drinking water intake locations is still preliminary, no surface-water sources of drinking water appear in the high-use area of the Georgia coastal plain.

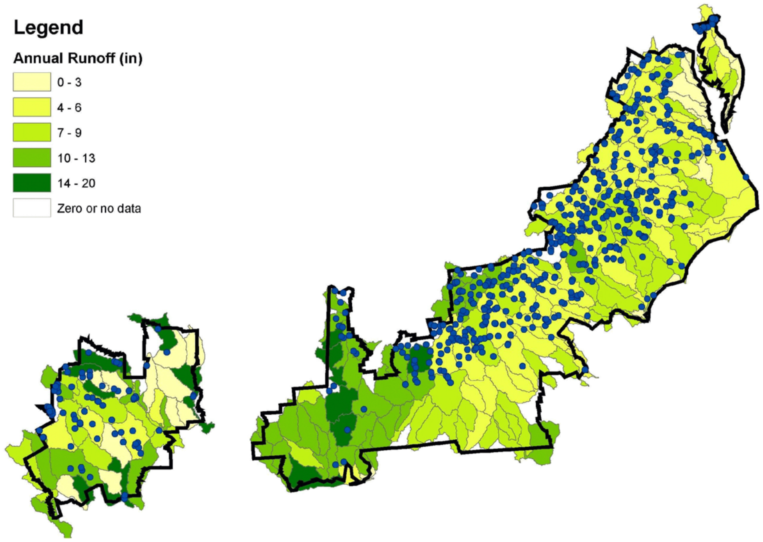


Figure II.F.3. Locations of surface water intakes of drinking water (shown as dots) in relation to average annual runoff (color gradation) in the Southern Seaboard Region

A large number of people living on the Coastal Plain derive drinking water from domestic wells in unconsolidated, surficial aquifers which are vulnerable to contamination. The Coastal Plain widens from north to south in this region. Ground water is the main source of drinking water in much of southern Alabama, southern Georgia, and eastern South Carolina. Surficial aquifers provide drinking water in coastal South Carolina and southeastern Georgia. These deposits are underlain in parts of all three states by the Floridan aquifer, which is described in the Southeast Fruitful Rim assessment, and the less productive Southeastern Coastal Plain aquifer system http://capp.water.usgs.gov/gwa/ch_g/jpeg/G008.jpeg .

The Floridan aquifer is a highly productive carbonate rock (e.g. limestone) aquifer which is an important source of drinking water in Alabama, Georgia, South Carolina and Florida. As described in the Apalachicola-Chattahoochee-Flint River Basin NAWQA study report, the recharge areas of the Floridan aquifer can be highly vulnerable karst regions. In other areas, such as much of southeastern Georgia, the Floridan is confined by at least 100 feet of fine sediments, which reduces the likelihood of direct contamination from the surface http://capp.water.usgs.gov/gwa/ch_g/jpeg/G055.jpeg .

The Southeastern Coastal Plain aquifer is most important as a drinking water source in the inner portion of the Coastal Plain. It is separated from the overlying Floridan by a clayey confining unit in Alabama and western Georgia, which serves to retard recharge from the Floridan, along with potential contamination from the surface. It is most productive away from the coast, where it is comprised of less sand and more clay.

Ground water is also an important source of drinking water on the Delmarva Peninsula, and in parts of coastal Virginia and North Carolina. Thick layers of sediment in this region (about 10,000 feet at Cape Hatteras, North Carolina) overlie bedrock similar to that exposed in the Piedmont physiographic province. These sediments were deposited as layers of sand overlain by finer sediments as the ocean advanced and retreated over the area. As a result, 11 aquifers comprise the Coastal Plain sediments in these states, separated by nine clay and silt confining units. Domestic wells drawing from the unconfined surficial aquifer will be the most vulnerable to contamination. Domestic or public supply wells drawing from deeper confined aquifers are less so.

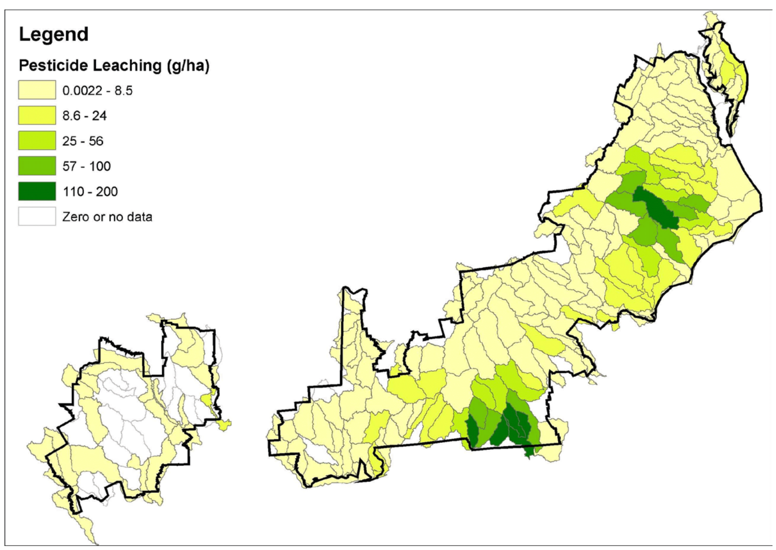


Figure II.F.4. Vulnerability of ground water resources to pesticide leaching in the Southern Seaboard, adapted from USDA (Kellogg, 1998)

In summary, only the high OP use area in eastern North Carolina, and a smaller area in eastern South Carolina, have the potential to impact vulnerable surface water sources of drinking water. The high OP use area in southern Georgia is located in an area where ground water is the predominant source of drinking water. Although available monitoring data is not extensive throughout the entire region, an evaluation of this data, discussed below, indicates that surface water sources of drinking water are likely to be more vulnerable than ground water sources. Based on the weight of evidence, the Agency believes that a surface water assessment based in eastern North Carolina is representative of the more vulnerable areas within the Southern Seaboard region. 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 Southern Seaboard cumulative assessment using PRZM-EXAMS output with various input parameters that are specific, where possible, to eastern North Carolina. Table II.F.5 presents pesticide use statistics for the OP-crop combinations 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 OP-use combinations represent roughly 87 percent of agricultural use of OP pesticides in these counties.

Table II.F.5. OP-Crop Combinations Included in the Southern Seaboard 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)
Terbufos	Corn	38	1.14	Ground; Planting	April 17	Apr1-May20 (Apr 10-Apr 25)
Chlorpyrifos	Corn	8	1.17	Ground; Planting	April 17	Apr1-May20 (Apr 10-Apr 25)
Acephate	Cotton	16	0.27	Ground; Foliar	June 11	May 1-Jul 21
Dimethoate	Cotton	2	0.1	Ground; Foliar	May 1, Jun 11	May 1-Jul 21
Phorate	Cotton	4	0.9	Ground; Planting	May 10	Apr21-Jun8 (May 1-May 20)
Tribufos	Cotton	39	0.46	Ground; Harvest	Oct 19	Sep27-Dec15 (Oct 7-Nov 15)
Disulfoton	Cotton	11	0.66	Ground; Planting	May10	Apr21-Jun8 (May-May 20)
Acephate	Peanuts	5	0.47	Ground; Planting-Foliar	May25	Apr28-Jun21
Chlorpyrifos	Peanuts	25	0.63	Ground; Foliar (Southern corn rootworm)	July 7	Jun15-Aug1
Phorate	Peanuts	20	0.91	Ground; Planting	May 18	Apr28-Jun2 (May 8-May 28)
Acephate	Tobacco	70	0.75	Ground; Foliar	June 30	May15-Aug15
Chlorpyrifos	Tobacco	25	2.3	Ground; Planting	May 16	Apr 18-Jun 2 (May 7-May 25)
Ethoprop	Tobacco	6(5.5)	5.2	Ground; Planting	May 16	Apr 18-Jun 2 (May 7-May 25)
Fenamiphos	Tobacco	15	3	Ground; Planting	May 16	Apr 18-Jun 2 (May 7-May 25)

Figure II.F.5 displays 35 years of predicted OP cumulative concentrations for the Southern Seaboard drinking water assessment. This chart depicts a single peak occurring each year, with year 3 having a higher peak than other years. The OP cumulative concentration levels exceeded 1 ppb in methamidophos equivalents during one (Year 3) of the 35 years modeled.

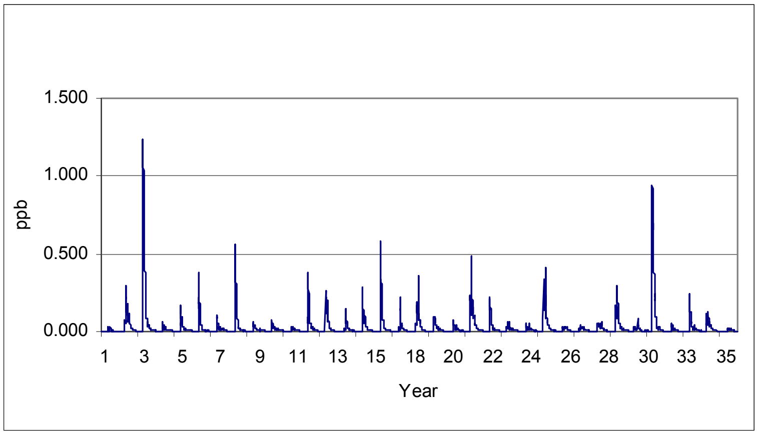


Figure II.F.5. Cumulative OP Distribution in Water in the Southern Seaboard (Methamidophos equivalents)

Figure II.F.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 110 (mid-late April).

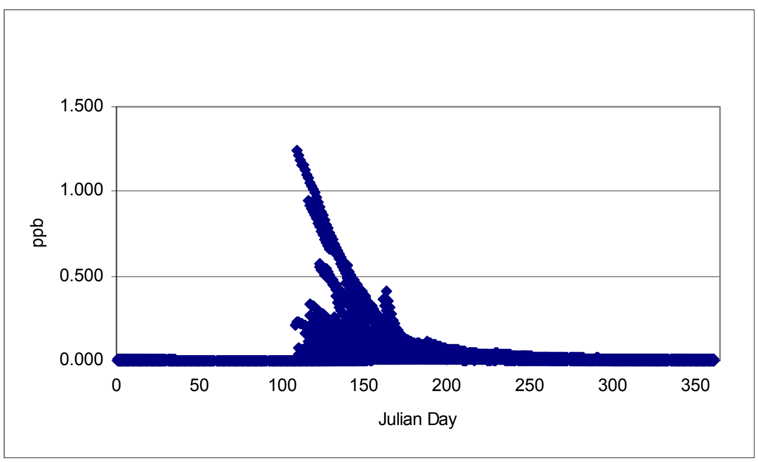


Figure II.F.6. Cumulative OP Distribution in Water (Methamidophos Equivalents) in the Southern Seaboard, summarized on a daily basis over 35 years

Figure II.F.7 depicts the predicted OP cumulative concentration for uses that made significant contributions during Year 3, the year in which the highest modeled concentration occurred. Terbufos use on corn was the primary contributor to that peak. Terbufos is applied to corn during the third week of April (4/17). 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.

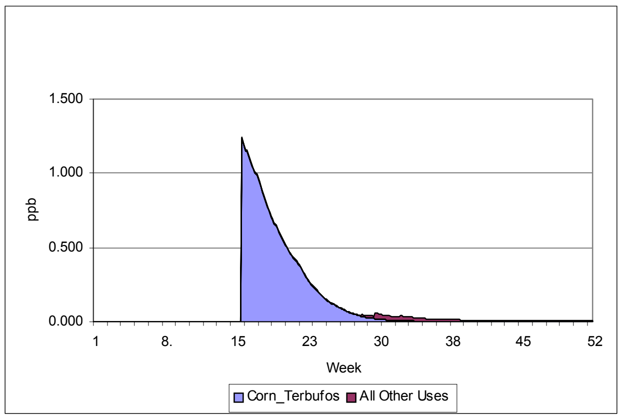


Figure II.F.7. Cumulative OP Distribution for an Example Year (Year 3) in the Southern Seaboard Region Showing Relative Contributions of the Individual OPs in Methamidophos Equivalents

c. A Comparison of Monitoring Data versus Modeling Results

A comparison of estimated concentrations for individual OP pesticides (Table II.F.6) with NAWQA monitoring (summarized below and in Appendix III.E.1) indicate that the predicted concentrations of OPs in surface water in eastern North Carolina are generally within the range of detections reported in the monitoring studies.

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

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	3.6e-01	1.5e-01	8.0e-02	5.1e-02	2.9e-02	2.3e-02	7.0e-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	Cotton	4.1e-02	2.6e-02	1.5e-02	1.1e-02	7.0e-03	5.7e-03	2.7e-03
Ethoprop	Tobacco	2.2e-01	1.4e-01	4.8e-02	2.9e-02	1.5e-02	1.2e-02	4.9e-03
Fenamiphos	Tobacco	3.3e-01	1.7e-01	4.9e-02	2.4e-02	1.0e-02	7.5e-03	2.3e-03
Methamidophos	Cotton, Peanut, Tobacco	2.1e-01	5.2e-03	1.7e-04	9.8e-06	4.5e-08	1.4e-08	4.2e-10
Phorate	Cotton, Peanut	6.6e-01	3.9e-02	1.6e-03	4.1e-05	1.7e-09	1.5e-11	1.3e-12
Terbufos	Corn	1.5e+00	3.7e-01	9.6e-02	3.3e-02	4.5e-03	1.6e-03	5.3e-05
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, ppb)		1.2e+00	3.6e-01	1.2e-01	5.3e-02	2.3e-02	1.8e-02	6.1e-03

In evaluating these comparisons, it is important to realize that 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. 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. The main document provides a characterization of what the water exposure estimates represent and includes an analysis of the factors that most influence these estimated concentrations.

d. Summary of Available Monitoring Data for the Southern Seaboard

Available water monitoring which included analysis for OPs includes four NAWQA studies, and several State monitoring programs.

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.

Ground-water studies included single samples from 90 public supply, domestic, irrigation and industrial wells from throughout the study unit. Thirty wells each were sampled from the Piedmont, Sandhills and Floridan aquifers. Of the three, the Sandhills is the most vulnerable, as the Piedmont and Floridan underlie weathered bedrock and a clay confining layer, respectively. An agricultural land use study included single samples from 30 wells in row-crop areas, and an urban land-use study included single samples from 30 wells in commercial and residential areas.

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.

Only a few states in the Southern Seaboard region have included OP pesticides in their monitoring program (See Appendix III.E.2 for details on the state monitoring programs. In **Delaware**, chlorpyrifos was detected at a concentration of 0.75 ppb (LOD of 0.22 ppb) in a single domestic well screened between 33 and 38 feet. This detection resulted from the state's Pesticide Management Program and is included in the report, "The Occurrence and Distribution of Several Agricultural Pesticides in Delaware's Shallow Ground Water", 2000: http://www.udel.edu/dgs/pub/RI61.pdf

In **North Carolina**, none of sixteen OPs were detected in its "Interagency Study of the Impact of Pesticide Use on Ground Water in North Carolina," which took place between 1991 and 1995. The number of wells sampled for each OP is shown below:

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

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.

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 95th percentile values can be plotted, with 95th 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 eastern uplands population (e.g, those at the 95th percentile vs. 99th percentiles of exposure).

Figures III.N.2-1 through III.N.2-5 in Appendix N present the results of this cumulative risk analysis for Children, 1-2 years for a variety of percentiles of the Southern Seaboard population (95 th , 97.5 th , 99 th , 99.5 th , and 99.9 th). Figure III.N.2-6 through Figure III.N.2-10, Figure III.N.2-11 through Figure III.N.2-15, and Figure III.N.2-16 through Figure III.N.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 95th percentile graphs for children 1-2 years old, the 95 th percentile (total) exposure for children 1-2 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 Southern Seaboard population at the 95th percentile exposures throughout the year. Each "component" of this 95th 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

(Figure III.N.2-1 through Figure III.N.2-5): At the 95th percentile, exposures from the residential applications of OP pesticides do not substantially contribute to the overall exposure, accounting for <1% of total exposure. 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 crack and crevice and pest strip treatments. There are increases in drinking water concentrations near Julian day 110 which corresponds to April application of terbufos to corn. Nevertheless, 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 (via inhalation) become an increasingly dominant portion of the total exposure profile. This corresponds to use of DDVP products (pest strips and crack and crevice treatments). Drinking water exposures at these percentiles continue to be low and do not contribute in any significant manner to the overall risk picture. Throughout all percentiles examined, dermal and/or hand-to-mouth exposures from lawn uses are apparent in the overall risk picture but remain a small fraction (<1%) of total exposure.

b. Children 3-5 years old

(Figure III.N.2-6 through Figure III.N.2-10): As with Children 1-2, exposures from the residential applications of OP pesticides do not substantially contribute to the overall exposure to the pesticides in this region at the 95th percentile (accounting for <1% of total exposure). 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 crack and crevice and pest strip treatments. As noted before, 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 (via inhalation) become an increasingly dominant portion of the total exposure profile. This corresponds to use of DDVP pest strips and crack and crevice treatments. Drinking water exposures at these percentiles continue to be low and do not contribute in any significant manner to the overall risk picture. Throughout all percentiles examined dermal and/or hand-to-mouth exposures from lawn uses are apparent but contribute only a small fraction (<1%) of total exposure.

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

(Figure III.N.2-11 through Figure III.N.2-15 and Figure III.N.2-16 through III.N.2-20) At the 95th percentile, exposures from the residential applications of OP pesticides do not significantly contribute to the overall exposure, accounting for <1% of total exposure. 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, flea, and pest strip treatments. As noted before, 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 (via inhalation) become an increasingly dominant portion of the total exposure profile. This corresponds to use of DDVP pest strips and crack and crevice treatments. Drinking water exposures at these percentiles continue to be low and do not contribute in any significant manner to the overall risk picture. Throughout all percentiles examined, dermal exposures from lawn uses are apparent in the overall risk picture but remain a small fraction (<1%) of total exposure.