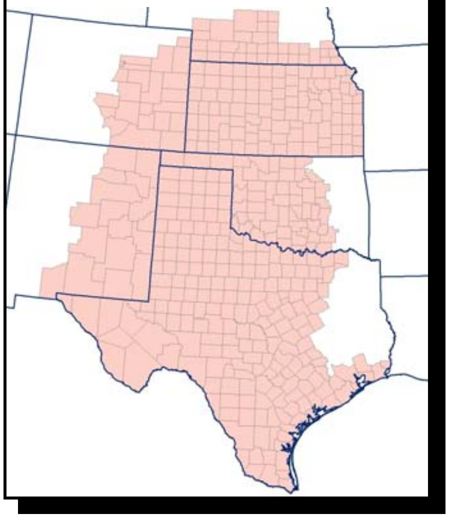
# II. Regional Assessments

## F. Region F - Lower Midwest Assessment

### 1. Executive Summary

Region F. Lower Midwest Assessment



This module of the Organophosphate (OP) cumulative risk assessment focuses on risks from OP uses in the Lower Midwest (area shown to the right). Information is included in this module only if it is specific to the Lower Midwest, or is necessary for clarifying the results of the Lower Midwest 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.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 Lower Midwest Residential/Non-Occupational and Drinking Water Assessment**

| Pesticide | Residential Use Scenarios | OP Drinking Water Scenarios |
|---|---|---|
| Acephate | Golf Courses, Ornamental Gardens | Cotton |
| Bensulide | Golf courses, Lawns | None |
| Chlorpyrifos | None | Corn, Cotton, Sorghum, Alfalfa |
| DDVP | Pest Strips | None |
| Dicrotophos | None | Cotton |
| Dimethoate | None | Cotton, Corn, Wheat |
| Disulfoton | Ornamental Gardens | None |
| Fenamiphos | Golf Courses | None |
| Malathion | Public Health,Ornamental Gardens, Fruit and Vegetable Gardens | Cotton |
| Methyl-parathion | None | Cotton, Alfalfa |
| Phorate | None | Cotton |
| TCVP | Pet Uses | None |
| Tebupirimphos | None | Corn |
| Terbufos | None | Corn |
| Tribufos | None | Cotton |
| Trichlorfon | Lawn Applications, Golf Courses | 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 Lower Midwest 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 Lower Midwest region is presented, focusing on aspects which are specific to this region.

In general, the risks estimated for the Lower Midwest 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 exposure, residential exposures though the inhalation route are the major source of risk - and are derived almost exclusively from use of DDVP pest strips. These patterns occur for all population sub-groups, although actual risks appear to be higher for children than for adults regardless of the percentile considered.

## 2. Development of Residential Exposure Aspects of Lower Midwest Region

In developing this component 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, pet uses, and use of pest strips. 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 proprietary 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 Lower Midwest. 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 pesticide for which these scenarios were used are presented in Table II.F.2 which summarizes all relevant region-specific scenarios.

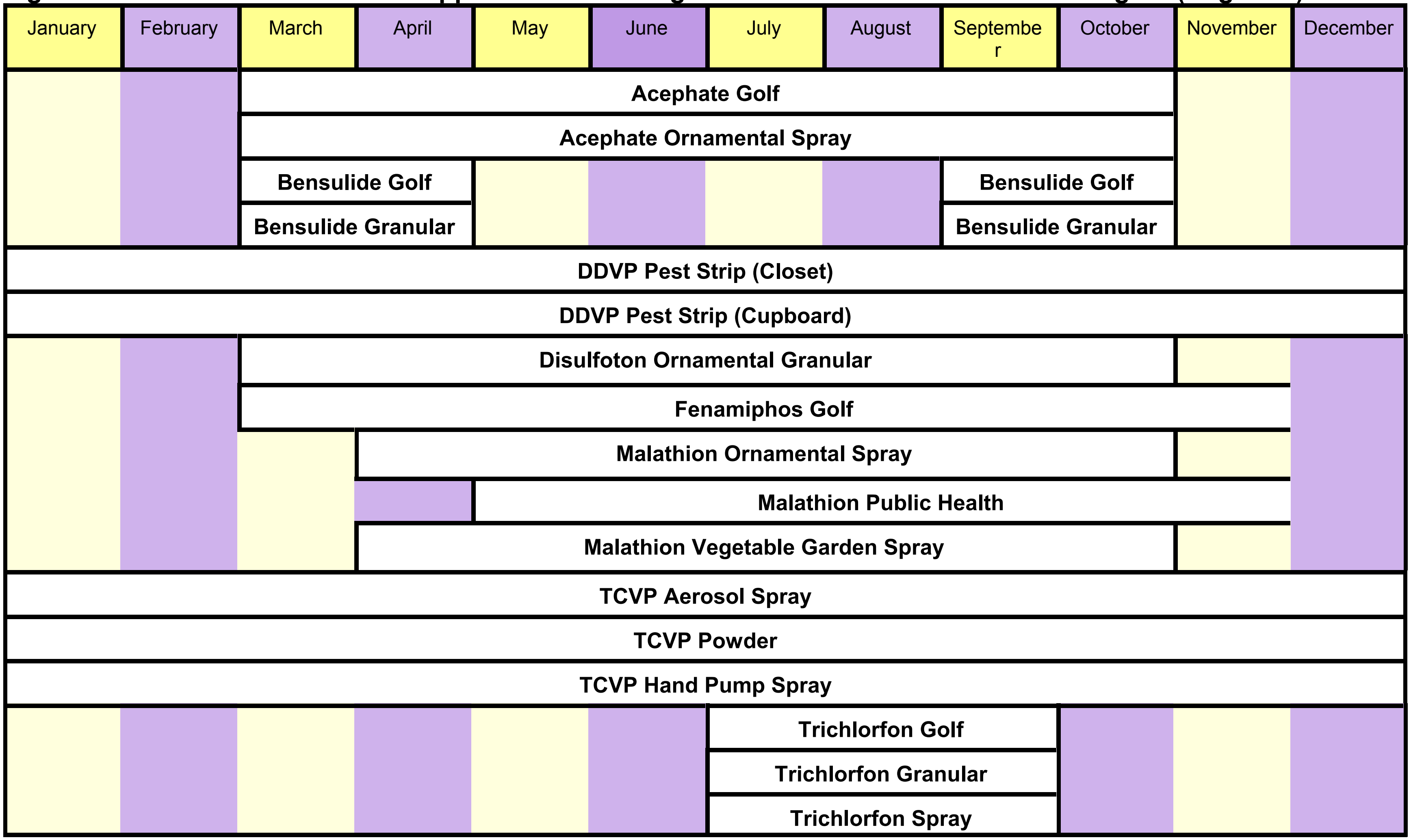
## Table II.F.2. Use Scenarios and Calendex Input Parameters for Lower Midwest Residential Exposure Assessment

| Chemical | Use Scenario | Application Method | Amt. Applied lb ai/A | Max. No./ Frequency Of Apps. | App. Schedule | % Use LCO | % Use HO | % Users | Residue Persistence (Days) | Routes of Exposure |
|---|---|---|---|---|---|---|---|---|---|---|
| Acephate | Golf Course | NA | 5 | 2/yr, 2 wks. Between Apps. | Mar.-Oct. 12-40 wks. | 100 | -- | 2 | 10 | dermal(p) |
| | Ornamental | hand pump sprayer | 0.9-2 | 4/yr, 2 wks. Between Apps. | Mar.-Oct. 12-40 wks. | -- | 100 | 6 | 1 | inhalation(a), dermal(a) |
| Bensulide | Golf Course | NA | 12.5 | 2/yr, 26 wks. Between Apps. | Mar.-Apr. and Sept.-Oct. | 100 | -- | 3 | 14 | dermal(p) |
| | Lawn | granular | 12.5 | 2/yr, 26 wks. Between Apps. | Mar.-Apr. and Sept.-Oct. | 9 | 91 | 1 | 1<br>14 | inhalation(a), oral(p), dermal(a)(p) |
| DDVP | Pest Strip | closet strip | NA | 16 wks., Regular App. Schedule | Jan.-Dec. 1-52 wks. | -- | 100 | 2 | 120 | inhalation(p) |
| | | cupboard strip | NA | 16 wks., Regular App. Schedule | Jan.-Dec. 1-52 wks. | -- | 100 | 2 | 120 | inhalation(p) |
| Disulfoton | Ornamental | granular | 8.7 | 3/yr, 6 wks. Between Apps. | Mar.-Oct. 12-40 wks. | -- | 100 | 2 | 1 | inhalation(a), dermal(a) |
| Fenamiphos | Golf Course | NA | 10 | 1/yr | Mar-Nov. 12-46 wks. | 100 | -- | 1 | 2 | dermal(p) |
| Malathion | Ornamental | hand pump spray | 0.9-2 | 2/yr, 2 wks. Between Apps. | Apr.-Oct. 14-42 wks. | -- | 100 | 4 | 1 | inhalation(a), dermal(a) |
| | Public Health | aerial and ground | NA | 10/yr, 2 wks. Between Apps. | May-Nov. 19-48 wks. | 100 | -- | 55 | 2 | oral(p), dermal(p) |
| | Vegetable Garden | hand pump sprayer | 1.5 | 5/yr, 2 wks. Between Apps. | Apr.-Oct. 14-42 wks. | -- | 100 | 1 | 1<br>14 | inhalation(a), dermal(a)(p) |
| TCVP | Pet Aerosol | aerosol spray | $2.4 \times 10^{-5}$- $3.3 \times 10^{-5}$ lb ai/lb dog | 1/8 wks., Regular App. Schedule | Jan.-Dec. 1-52 wks. | -- | 100 | 5 | 1<br>32 | inhalation(a), oral(p), dermal(a)(p) |

| Chemical | Use Scenario | Application Method | Amt. Applied lb ai/A | Max. No./ Frequency Of Apps. | App. Schedule | % Use LCO | % Use HO | % Users | Residue Persistence (Days) | Routes of Exposure |
|---|---|---|---|---|---|---|---|---|---|---|
|  | Pet Powder | shaker can | $4.6 \times 10^{-5}$-<br>$5.5 \times 10^{-5}$<br>lb ai/lb dog | 1/8 wks., Regular App. Schedule | Jan.-Dec.<br>1-52 wks. | -- | 100 | 5 | 1<br>32 | inhalation(a),<br>oral(p), dermal(a)(p) |
|  | Pet Spray | hand pump sprayer | $2.0 \times 10^{-5}$-<br>$2.2 \times 10^{-5}$<br>lb ai/lb dog | 1/8 wks., Regular App. Schedule | Jan.-Dec.<br>1-52 wks. | -- | 100 | 5 | 1<br>32 | inhalation(a),<br>oral(p), dermal(a)(p) |
| Trichlorfon | Golf Course | NA | 8 | 1/yr | Jul.-Sept.<br>30-36 wks. | 100 | -- | 1 | 2 | dermal(p) |
|  | Lawn Granular | rotary spreader | 8 | 1/yr | Jul.-Sept.<br>30-36 wks. | 8 | 91 | 1 | 1<br>2 | inhalation(a),<br>oral(p), dermal(a)(p) |
|  | Lawn Spray | NA | 8 | 1/yr | Jul.-Sept.<br>30-36 wks. | 100 | -- | 2 | 2 | oral(p), dermal(p) |

(a) = applicator exposure
(p) = post application exposure
Note: For applicator dermal exposure, the residue persistence is 1 day.

**Figure II.F.1 Residential Scenario Application and Usage Schedules for Lower Midwest Region (Region F)**



| | January | February | March | April | May | June | July | August | September | October | November | December |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Acephate Golf | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| Acephate Ornamental Spray | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| Bensulide Golf | | | ■ | ■ | | | | | ■ | ■ | | |
| Bensulide Granular | | | ■ | ■ | | | | | ■ | ■ | | |
| DDVP Pest Strip (Closet) | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| DDVP Pest Strip (Cupboard) | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Disulfoton Ornamental Granular | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| Fenamiphos Golf | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | |
| Malathion Ornamental Spray | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| Malathion Public Health | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | |
| Malathion Vegetable Garden Spray | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| TCVP Aerosol Spray | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| TCVP Powder | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| TCVP Hand Pump Spray | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Trichlorfon Golf | | | | | | | ■ | ■ | ■ | | | |
| Trichlorfon Granular | | | | | | | ■ | ■ | ■ | | | |
| Trichlorfon Spray | | | | | | | ■ | ■ | ■ | | | |

### 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 a period of 10 days after treatment (Days 0, 1, 2, 3, 5, 7, and 10 days). For each day following application, a residue value from a uniform distribution bounded by the low and high measurements for each day was selected. No half-life value or other degradation parameter was used, with 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 dissipation study was conducted with multiple residue measurements collected up to 7 days after treatment in Pennsylvania. 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.

#### iv. Fenamiphos

Snyder et al., 1999 collected residue dissipation data on the day of and day after application following the application of fenamiphos on a golf course. Only mean measurements were collected.

#### v. 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. This was used for the lawn post-application exposure scenarios. For dermal exposure scenarios, 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 sprayable formulations respectively). These distributions also reflect actual measurements including those based on directions to water in the product. 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 Lower Midwest 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 Lower Midwest region. This region combines the Prairie Gateway and Texas Fruitful Rim regions from the preliminary assessment. The selection process considers OP usage and the relative potencies of those OP pesticides being used and the location, nature, and vulnerability of the drinking water sources. The methods used to identify a specific location within the region are described in the main document (Section I.E). The following discussion provides the details specific to the Lower Midwest regional assessment for OP cumulative drinking water exposure. The discussion centers on four main aspects of the assessment: (1) the selection of the Central Hills of Texas for the drinking water assessment, (2) predicted cumulative concentrations of OPs in surface water for those OP-crop uses included in this regional assessment, (3) a comparison of the predicted concentrations used in the regional assessment with 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 the Central Hill Region of Texas for Drinking Water Assessment

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 this Central Hills region of Texas (Williamson, Milam, Bell, Falls, Hill, McLennan, Navarro, and Ellis counties) will represent one of the more vulnerable sources of drinking water in the region.

Total OP usage is relatively high in the region. In 1997, nearly 9 million pounds (ai) of OPs were applied to agricultural crops. Cotton, corn, alfalfa, wheat, and sorghum accounted for 94% of OP usage in the Lower Midwest region (Table II.F.3).

**Table II.F.3. General overview of OP usage in the Lower Midwest Region.**

| Crops | Primary Production Areas | Total Pounds Applied | Percent of Total OP Use |
|---|---|---|---|
| Cotton | Texas, Oklahoma | 3,462,000 | 39 |
| Corn | Nebraska and Kansas, with additional use in central/south Texas | 2,188,000 | 25 |
| Alfalfa | Higher use in the northern part of the region | 1,297,000 | 15 |
| Wheat | Kansas, western Oklahoma | 726,000 | 8 |
| Sorghum | Throughout the region | 585,000 | 7 |
| Pecans | Texas | 233,000 | 3 |
| Vegetables | Rio Grande Valley, TX | 116,000 | 1 |
| | | 8,897,000 | 98 |

(1) Source: NCFAP, 1997.

The highest OP use area occurs in western Texas (Figure II.F.2), with cotton as the dominant OP-use crop. Other areas of relatively high OP use include southern Nebraska, at the northern end of the region, southwestern Oklahoma, the Central Hills of Texas, and the southern tip of Texas. Cotton is also the dominant OP-use crop in southwestern Oklahoma. Corn, alfalfa, and sorghum are the dominant OP-use crops in southern Nebraska. Corn, cotton, alfalfa, and sorghum were dominant in the Central Hills of Texas.

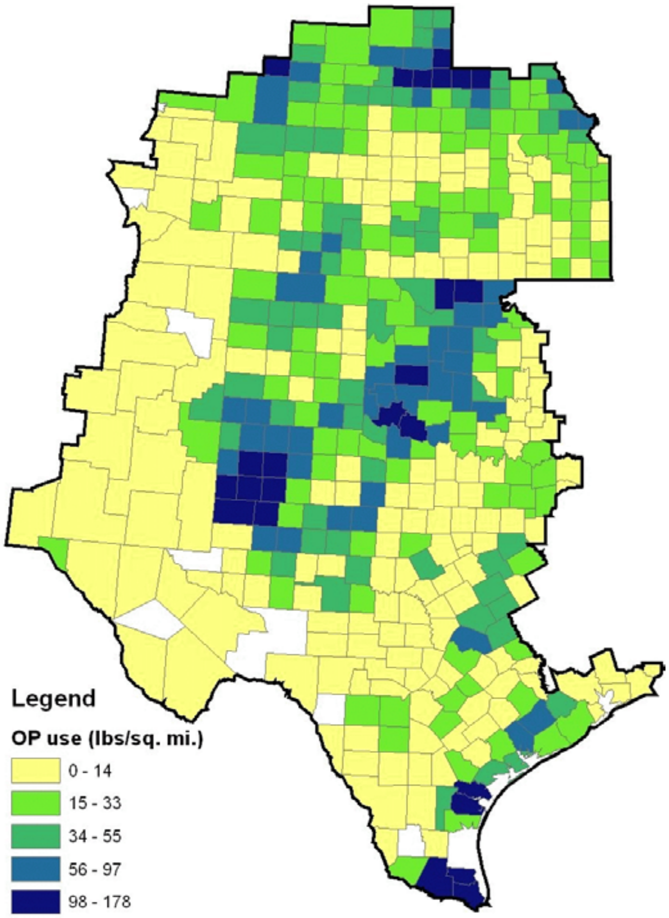


**Figure II.F.2. Total OP usage (pounds per area) in the Lower Midwest Region (source: NCFAP, 1997)**

Surface water sources of drinking water are common in the eastern portion of the region, extending from eastern Kansas south into central Oklahoma and Texas (Figure II.F.3). Additional surface water intakes are found along the western edge in central Colorado. Many large metropolitan areas in the Prairie Gateway, such as Oklahoma City and Tulsa, OK, and Dallas, Fort Worth, Houston, and Austin, TX, are supplied largely or entirely by surface water.

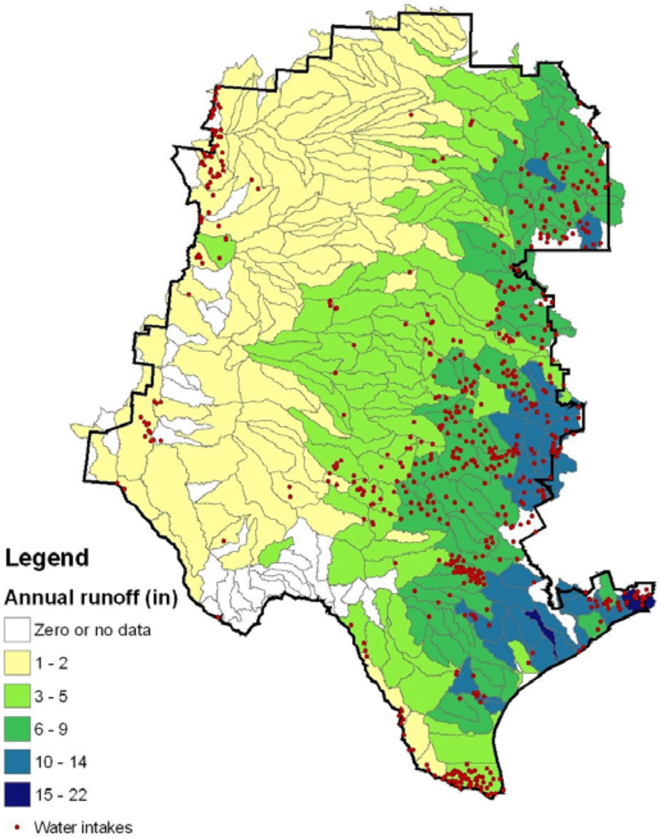


**Figure II.F.3. Locations of surface water intakes of drinking water in relation to average annual runoff in the Lower Midwest Region.**

Surface water sources of drinking water in the eastern portion of the region are more vulnerable to runoff. Watersheds with the greatest runoff potential in the region are found in the southeastern part of the region, in central Oklahoma and Texas. Of the relatively high OP use areas, surface water sources of drinking water in the Central Hills area of Texas are the most potentially vulnerable to pesticide runoff. Fewer surface water sources of drinking water occur in the west Texas and southern Nebraska use areas; these areas are also less prone to runoff.

Ground water serves as a drinking water source for about 42 percent of the population of Oklahoma and Texas, including San Antonio and El Paso, 86 percent of the population of Nebraska, and 52 percent of people in Kansas (see http://capp.water.usgs.gov/gwa/ch_d/gif/Dtab1.GIF ). Ground water is the main source of drinking water for people in rural areas throughout these states.

The geology of the major aquifers influences the relative vulnerability of ground-water sources of drinking water in the region (Figure II.F.4). Unconsolidated surficial sand and gravel aquifers are the most important source of ground water used as drinking water in the region. Aquifers in these alluvial or glacial sediments (see http://capp.water.usgs.gov/gwa/ch_d/gif/D013.GIF ) average 90 to 100 feet in thickness, with a saturated thickness ranging from 50 to 80 feet. These shallow sand and gravel aquifers are vulnerable to pesticide contamination.

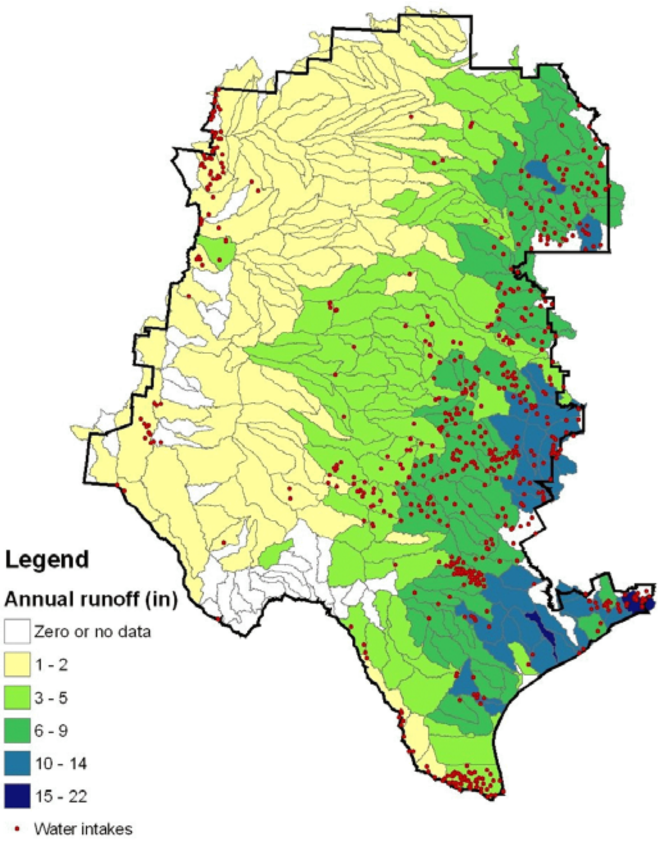


**Figure II.F.4. Vulnerability of ground water resources to pesticide leaching in the Lower Midwest Region, adapted from USDA (Kellogg, 1998).**

The city of San Antonio derives its water mainly from the bedrock Edwards aquifer. Although this aquifer is confined throughout most of its extent, streams and precipitation recharge it quickly at its fractured and faulted outcrop. The less permeable Trinity aquifer, which overlies the Edwards, is the main source of water for the Texas Hill Country near San Antonio.

The High Plains aquifer, which is also an unconsolidated sand and gravel aquifer under water-table conditions, is a much more important source of ground-water, overall. However, because of high levels of suspended sediment, sodium, and fluoride, it is used primarily as a source of irrigation water. In 1990, less than 3% of the water withdrawn from the High Plains aquifer was used for public supply (Water Atlas).

The depth to water in the High Plains aquifer is shallow (less than 200 feet in Kansas and Nebraska, often <100 feet elsewhere), and is usually hydraulically connected with the overlying unconsolidated surficial aquifers, where they occur. Because of this, the High Plains is also vulnerable to contamination. The High Plains underlies parts of all the states in the Prairie Gateway, as well as parts of South Dakota and Wyoming. The aquifer is often called the Ogallala in Texas and Oklahoma.

Based on the weight of evidence, the Agency believes that a surface water assessment based in the Central Hills of Texas is representative of the more vulnerable areas within the Lower Midwest 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.

In the Central Hills of Texas (Bell, Ellis, Falls, Hill, McLellan, Milam, Navarro, and Williamson counties), OP use on corn, cotton, sorghum, and wheat accounted for 95% of total agricultural use (Table II.F.4).

**Table II.F.4. OP Usage on Agricultural Crops in East-Central Texas (Williamson, Milam, Bell, Falls, Hill, McLennan, Navarro, and Ellis Counties)**

| **OP Usage/ Agricultural Crops** | | | | **Cropland Acreage, Assessment Area** | |
|---|---|---|---|---|---|
| **Crop Group** | **Crops** | **OP Usage x 1000 lb** | **Percent of Total OP Use** | **Acres** | **Pct of total Cropland** |
| Cotton | Cotton | 424 | 81 | 131 | 6 |
| Corn | Corn | 63 | 12 | 405 | 20 |
| Sorghum | Sorghum | 4 | 1 | 200 | 10 |
| Wheat | Wheat | 3.5 | 1 | 249 | 12 |
| | | | 95 | 986 | 48 |

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

### b. Cumulative OP Concentration Distribution in Surface Water

The Agency estimated drinking water concentrations for the Lower Midwest regional assessment using PRZM-EXAMS with input parameters specific to the Central Hills region in east Texas. Table II.F.5 summarizes pesticide use information for the OP-crop combinations included 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.

**Table II.F.5. OP-Crop combinations and application information for the Lower Midwest Region 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 | 4 | 0.76 | Ground; Planting | April 9 | Feb28-May15 (Mar 20 - Apr 29) |
| Dimethoate | Corn | 5 | 0.43 | Aerial; Foliar | July 1 | Jun1-Aug1 |
| Phostebupirim (tebupirimphos) | Corn | 8 | 0.08 | Ground; Planting | April 9 | Feb28-May15 (Mar 20-Apr 29) |
| Terbufos | Corn | 12 | 0.82 | Ground; Planting | April 9 | Feb28-May15 (Mar 20-Apr 29) |
| Acephate | Cotton | 6 | 0.57 | Ground; Foliar | May 1, May 21 | May1-Jun 10 |
| Chlorpyrifos | Cotton | 5 | 0.64 | Aerial; Foliar | Jun 15, Jul 16 | Jun15-Aug15 |
| Dicrotophos | Cotton | 5 | 0.14 | Ground; Foliar | May 1, May 24 | May1-Jun15 |
| Malathion | Cotton | 41 | 1.02 | Ground; Foliar | May 15 | May 15-Oct 15 |
| | | | | Aerial; Foliar | Jun 6,Jun 28, Jul 20, Aug. 11, Sep. 2, Sep. 24 | |
| Methyl parathion | Cotton | 6 | 0.64 | Ground; Foliar | May 15 | May 15-Oct 15 |
| | | | | Aerial; Foliar | July 31 | |
| Phorate | Cotton | 4 | 0.44 | Ground; Planting | April 13 | Mar20-Jun1 (Apr 1-Apr 25) |
| Dimethoate | Cotton | 2 | 0.24 | Ground; Foliar | May 1, May 24 | May1-Jun15 |
| Tribufos | Cotton | 11 | 0.51 | Aerial; Foliar | Nov. 1 | Aug10-Dec28 (Oct 1 - Dec 2) |
| Chlorpyrifos | Sorghum | 5 | 0.44 | Aerial; Foliar | May 2 | Apr1-Jun1 |
| Dimethoate | Wheat | 5 | 0.28 | Aerial; Foliar | Nov. 8 | Oct15-Dec1 |
| Chlorpyrifos | Alfalfa | 10 | 0.55 | Foliar | June 16 | May15-Jul15 |
| Methyl parathion | Alfalfa | 3 | 0.19 | Foliar | June 16 | May15-Jul15 |

Estimated maximum concentrations of malathion, terbufos (parent plus sulfoxide/sulfone), and the cumulative OP load (methamidophos equivalents) were in the single parts per billion. Except for terbufos, estimated 99th percentile concentrations of all OPs were less than 0.1 ppb (Table II.F.6).

**Table II.F.6. 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 |
| Dicrotophos | 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 (tebupirimphos) | 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 |

Figure II.F.5 displays 33 years of predicted OP cumulative concentrations for the region. Peak OP cumulative concentrations equaled or exceeded 2 ppb in methamidophos equivalents 12% of the time (4 of 33 years modeled) and 1 ppb 24% (8 of 33 years) of the time.

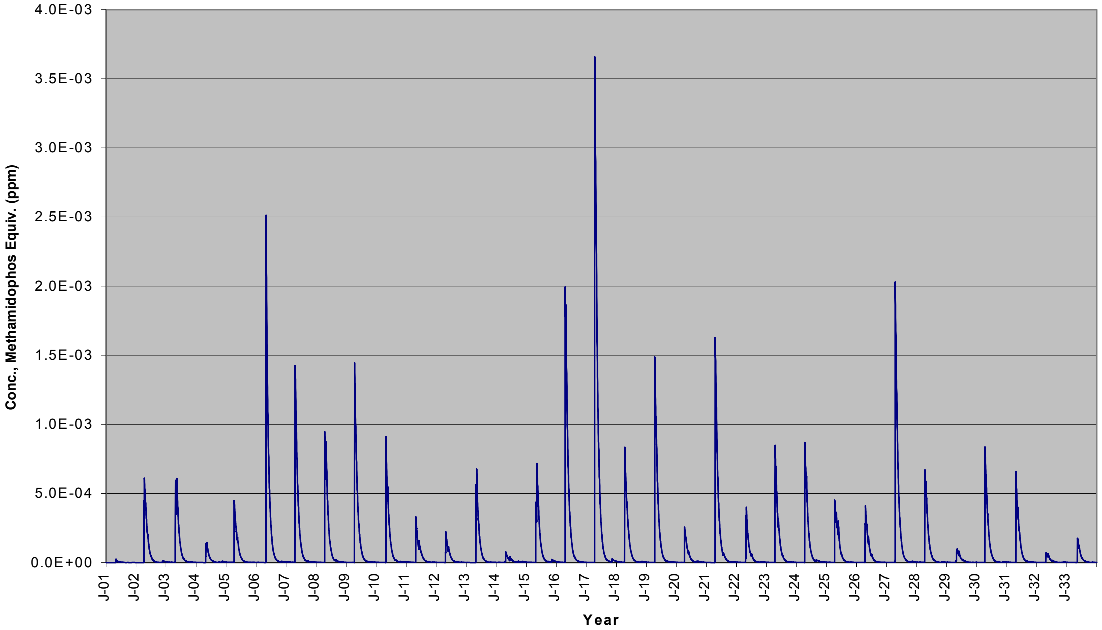


**Figure II.F.5. Cumulative OP distribution in water in the Lower Midwest Region across 33 years of weather patterns.**

Peak cumulative OP loads tend to occur between mid-April and mid-May in most years (Figure II.F.6), depending on the timing of runoff-producing rain. Estimated OP loads in the region decline rapidly during late spring into early summer.

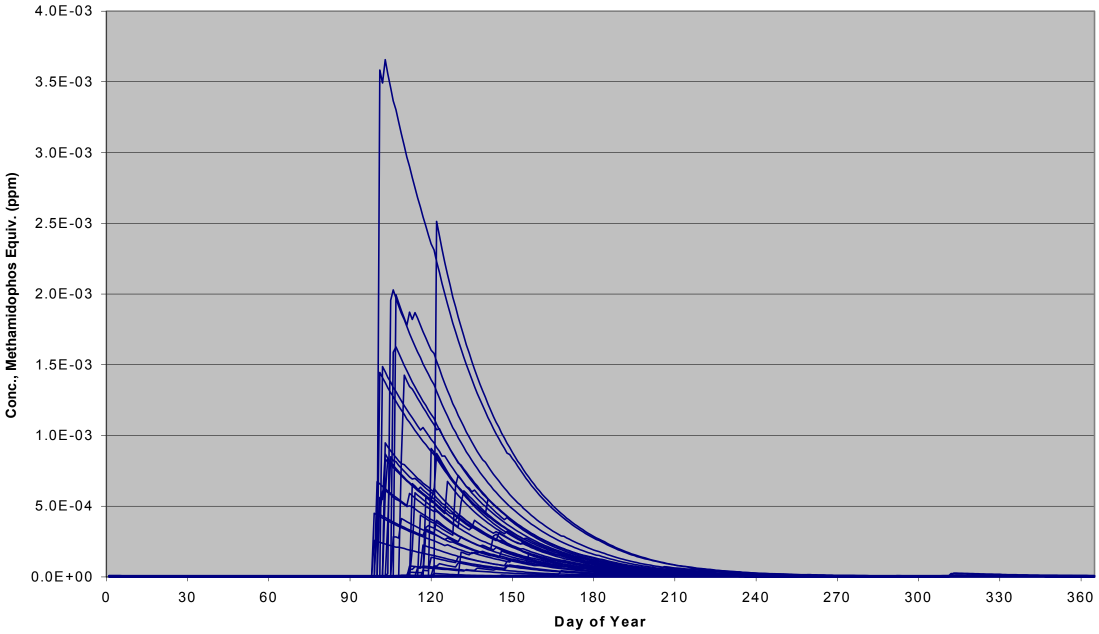


**Figure II.F.6. Variations in yearly pattern of cumulative OP concentrations in water in the Lower Midwest Region (33 years of varying weather patterns).**

Terbufos, used on corn, is the major contributor to estimated cumulative OP levels in water in the region, comprising nearly the entire peak load in most years (Figure II.D.7). Phostebupirim, also applied to corn around the same time, contributed to the peak at levels of at least two orders of magnitude lower than terbufos. The relative contributions are the result of both individual chemical concentrations in water and their relative potency and safety factors.

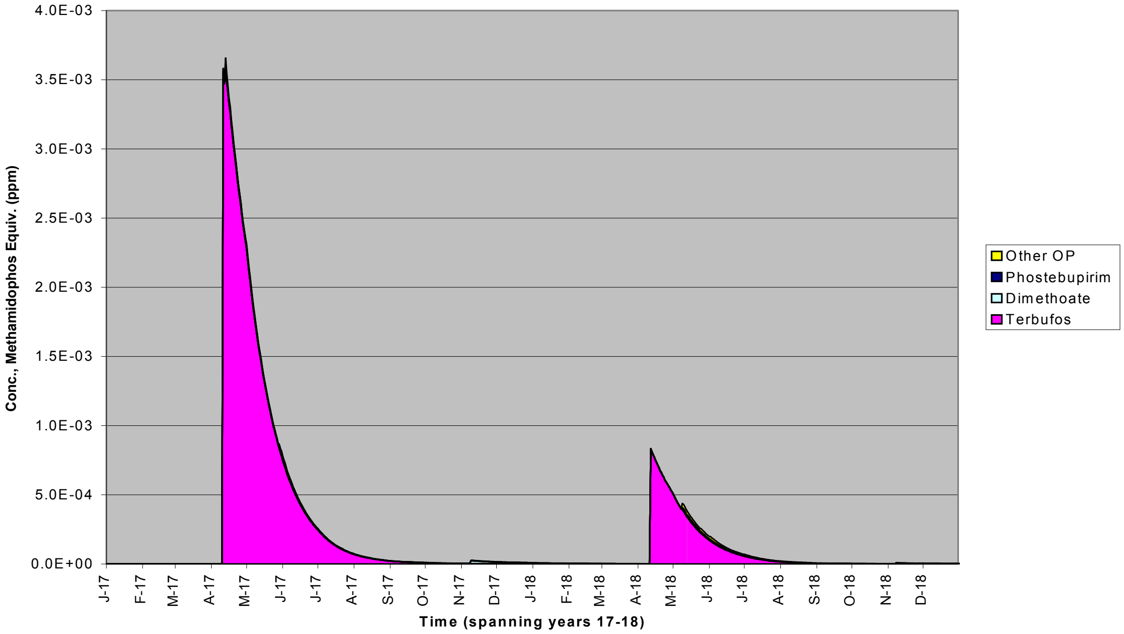


**Figure II.F.7. Cumulative OP distribution spanning 2 years showing relative contributions of the individual OPs in methamidophos equivalents, Lower Midwest Region**

### c. A Comparison of Monitoring Data versus Modeling Results

A comparison of estimated concentrations for individual OP pesticides with NAWQA monitoring (summarized below and in Appendix III.E.1) 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.

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.

Lake Waxahachie (TX), included in the USGS-EPA reservoir monitoring study, is representative of cotton cropping in central Texas (Blomquist et al, 2001; Appendix III.E.3). Only diazinon was detected in samples taken from the reservoir in 1999 (no samples were taken in 2000). However, 90 to 99% or more of estimated concentrations of dicrotophos, dimethoate, methyl parathion, phorate, phostebupirim, and tribufos were less than the USGS analytical limits of detection (LOD). Only estimated concentrations of chlorpyrifos were noticeably greater than what was found in Lake Waxahachie (50% of estimated concentrations above the LOD). More information on weather (in comparison to the range in expected conditions) and OP use in the watershed is needed to put this comparison into context.

### d. Summary of Available Monitoring Data for the Lower Midwest

Monitoring data are available from USGS NAWQA program and from several state programs. Chlorpyrifos, diazinon, and malathion were the most frequently detected OPs in surface water; methyl parathion, azinphos-methyl, disulfoton, and terbufos were detected less frequently in surface water. Although aquifers in the Lower Midwest are somewhat susceptible to contamination, only rare detections of diazinon and chlorpyrifos are reported in the available monitoring data.

The Lower Midwest includes three USGS National Water Quality Assessment (**NAWQA**) study units.

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 of the study was to examine 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 mixe-use streams, while the 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.

The **Trinity River Basin (TRIN)** study unit is the NAWQA monitoring program closest to the Central Hills area used for the regional drinking water assessment. 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 ug/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 ug/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 ug/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).

Only a few **state monitoring programs** have included any OP pesticides in their programs. In **Kansas**, only diazinon has been detected in their routine ambient surface water quality sampling network. Since 1995, 44 detections were found at 16 urban or golf course sites, with detections ranging from 0.19 to 1.5 micrograms/liter. A Kansas Department of Agriculture study of chemigation wells is designed “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. **Nebraska** has no record of OP detections in its “Quality-Assessed Agricultural Contaminant Database for Nebraska Ground Water.” OPs are not included in surface-water monitoring in Nebraska.

## 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. Briefly, the cumulative assessment single day analysis generates multiple potential exposures (i.e., distribution of exposures for each of the 365 days of the year) 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. 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 evaluated as a function of time. That is, for example, a 365-day series of 95th percentile values can be arrayed, 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" 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) can be observed and compared. Abrupt changes in the slope or levels of such a profile may indicate some combination of exposure conditions resulting in an altered risk profile due to a variety of factors. Factors causing this alteration 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 at various total exposure levels for different subgroups of the Lower Midwest output distribution (e.g, those at the 95th percentile vs. 99th percentiles of exposure).

Figures III.O.2-1 through III.O.2-8 in Appendix O present the results of this cumulative risk analysis for Children, 1-2 years for a variety of percentiles (95, 99, 99.5, and 99.9) of the Lower Midwest output distribution for two averaging periods (one and seven days). Figure III.O.2-9 through Figure III.O.2-16 present these same figures for Children 3-5. The data/output (ungraphed) for Adults 20-49 and Adults 50+ are presented in Appendix III.O.3. The following paragraphs describe, in additional detail, the exposure profiles for each of these age groups for the 99.9th and 95th percentile. Briefly, these figures present a series of time courses of exposure (expressed as MOEs) for various age groups at various percentiles of exposure. For example, for the 95th percentile MOEs 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 MOEs – arrayed as a function of time. The result is a “time course” (or “profile”) of exposures representing that portion of the Lower Midwest output distribution at the 95th percentile exposures throughout the year. In addition, the MOEs are shown for each pathway or route (e.g., oral ingestion through food, oral ingestion through hand-to-mouth activity, inhalation, dermal, etc.) for each of a variety of percentiles. 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

Single-Day Analysis (Figure III.O.2-1 through Figure III.O.2-4): At the 99.9th percentile exposure, total MOEs are ~ 9 to 60. The inhalation route from the use of DDVP pest strips is dominant (MOEs of ~ 10 to 100). At the 95th percentile, total MOEs are well above 100, and no exposure through the use of DDVP pest strips occurs. It is important to express these exposures as a *range* of MOEs because there may be variability across seasons. There are increases in drinking water concentrations beginning at about Julian Day 100 at all percentiles examined (95th through 99.9th ). These corresponds to April applications of phostebupirim and terbufos to corn. However, drinking water at these percentiles does not contribute substantial exposures and MOEs through this route remain above 100. Dermal and oral hand-to-mouth exposures also appear at these percentiles, but only as relatively small contributors to total exposure with MOEs that remain greater than 300 throughout the year.

Seven Day Rolling Average Analysis (Figure III.O.2-5 through Figure III.O.2-8): At the 99.9th percentile exposure, total MOEs are ~ 20 to 60. The inhalation route from the use of DDVP pest strips is dominant. At the 95th percentile, total MOEs are well above 100, and no exposure through the use of DDVP pest strips occurs. It is important to express these exposures as a *range* of MOEs because there may be variability across seasons. There are increases in drinking water concentrations beginning at about Julian Day 100 as described above, but drinking water at the percentiles examined (95, 99, 99.5, and 99.9) does not contribute substantial exposures and MOEs remain above 100. Dermal and oral hand-to-mouth exposure also appear at these percentiles, but are small contributors to total exposure with MOEs that generally remain greater than 1000 throughout the year.

### b. Children 3-5 years old

Single Day Analysis (Figure III.O.2-9 through Figure III.O.2-12). At the 99.9th percentile exposure, total MOEs are ~ 15 to 60. The inhalation route from the use of DDVP pest strips is the dominant contributor. At the 95th percentile, total MOEs are well above 100, and no exposure through the use of DDVP pest strips occurs. It is important to express these exposures as a *range* of MOEs because there may be variability across seasons. As indicated above, there are increases in drinking water concentrations at all percentiles examine (95, 99, 99.5, and 99.9) beginning at about Julian Day 100, but drinking water does not contribute to substantial exposures at any of these percentiles and MOEs through this route remain above 200. Dermal and oral hand-to-mouth exposure also appear at these percentiles, but, as before, are small contributor to total exposure with MOEs that generally remain greater than 1000 throughout the year.

Seven Day Rolling Average Analysis (Figure III.O.2-13 through Figure III.O.2-16). At the 99.9th percentile exposure, total MOEs are ~ 30 to 70. The inhalation route from the use of DDVP pest strips is the dominant contributor. At the 95th percentile, total MOEs are well above 100, and no exposure through the use of DDVP pest strips occurs. It is important to express these exposures as a *range* of MOEs because there may be variability across seasons. As indicated above, there are increases in drinking water concentrations beginning at about Julian Day 100, but drinking water at this percentile does not contribute to substantial exposures and MOEs through this route remain above 200 at all percentiles examined (95, 99, 99.5, and 99.9). Dermal and oral hand-to-mouth exposure also appear at this percentile, but as small contributors to total exposure with MOEs that remain greater than 1000 throughout the year.

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

Single Day Analysis (Appendix III.O.3) At the 99.9th percentile exposure, total MOEs are ~ 40 to 160. The inhalation route from the use of DDVP pest strips is the dominant contributor. At the 95th percentile, total MOEs are well above 100, and no exposure through the use of DDVP pest strips occurs. It is important to express these exposures as a *range* of MOEs because there may be variability across seasons. As indicated above, there are increases in drinking water concentrations at all percentiles examine (95, 99, 99.5, and 99.9) beginning at about Julian Day 100, but drinking water at these percentiles does not contribute to substantial exposures at any of these percentiles and MOEs through this route remain above 200. Dermal exposure also appears at these percentiles, but, as before, are small contributor to total exposure with MOEs that generally remain greater than 1000 throughout the year.

<u>Seven Day Rolling Average Analysis (Appendix III.O.3)</u> At the 99.9th percentile exposure, total MOEs are ~ 100 to 180. The inhalation route from the use of DDVP pest strips is the dominant contributor. At the 95th percentile, total MOEs are well above 100, and no exposure through the use of DDVP pest strips occurs. It is important to express these exposures as a *range* of MOEs because there may be variability across seasons. As all percentiles examined (95, 99, 99.5, and 99.9), drinking water at this percentile does not contribute to substantial exposures and MOEs through this route remain above 300. Dermal exposure also appears at these examined percentiles, but only as small contributors to total exposure with MOEs that remain greater than 1000 throughout the year.