Estimation of Exposures from Pesticide Products Containing Methyl Iodide

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Methyl iodide is being considered as one of the replacements for methyl bromide as a pre-plant soil-fumigant.

Comparison of Chemical/Physical Properties of Methyl Iodide and Methyl Bromide.

Property	Methyl Iodide	Methyl Bromide
Chemical Structure	**CH_3I**	**CH_3Br**
Molecular Weight	141.95 g/mole	94.95 g/mole
Specific Gravity	2.279 g/ml	1.7 g/ml
Boiling Point	42°C	3.56°C
Solubility in Water	1.42×10^4 ppm @ 25°C	1.75×10^4ppm @20°C
Vapor Pressure	398 mm Hg @ 25°C	1420 mm Hg @ 20 °C

USEPA-Registered Products Containing Methyl Iodide Proposed for California

Product Name	Formulation
Midas® 98:2	98% MI; 2% Chloropicrin
Midas® EC Bronze	50% MI; 45% Chloropicrin
Midas® 50:50	50% MI; 50% Chloropicrin
Midas® EC Gold	33% MI; 62% Chloropicrin
Midas® 33:67	33% MI; 67% Chloropicrin
Midas® 25:75	25% MI; 75% Chloropicrin

Types of Application Studies for Pre-Plant Soil Fumigation

Drip Irrigation
- Tarped/Raised Bed

Shallow Shank Injection
- Tarped/Raised Bed
- Tarped/Flat Fume

Application of Methyl Iodide by Drip Irrigation

Application of Methyl Iodide by Drip Irrigation

Tarped/Raised Bed Shallow-Shank Injection of Methyl Iodide

Tarped/Raised Bed Shallow-Shank Injection of Methyl Iodide

Tarped/Raised Bed Shallow-Shank Injection of Methyl Iodide

Label Requirements Affecting Exposure Estimates

- Handlers (including shovelers) must wear respiratory protection or work using engineering controls to reduce exposure.
- No more than 40 contiguous acres/day may be treated.
- No one many enter the buffer zone (490 feet near a 40 acre field fumigated @ 175 lb ai/treated acre) w/out respiratory protection for 48 hours.
- Buffer zones between treated fields and fields being treated may not overlap.

Calculation of the Upper-Bound Air Concentration Associated with Each Category of Handler

The upper-bound MI concentration for acute exposures is calculated by the following expression:

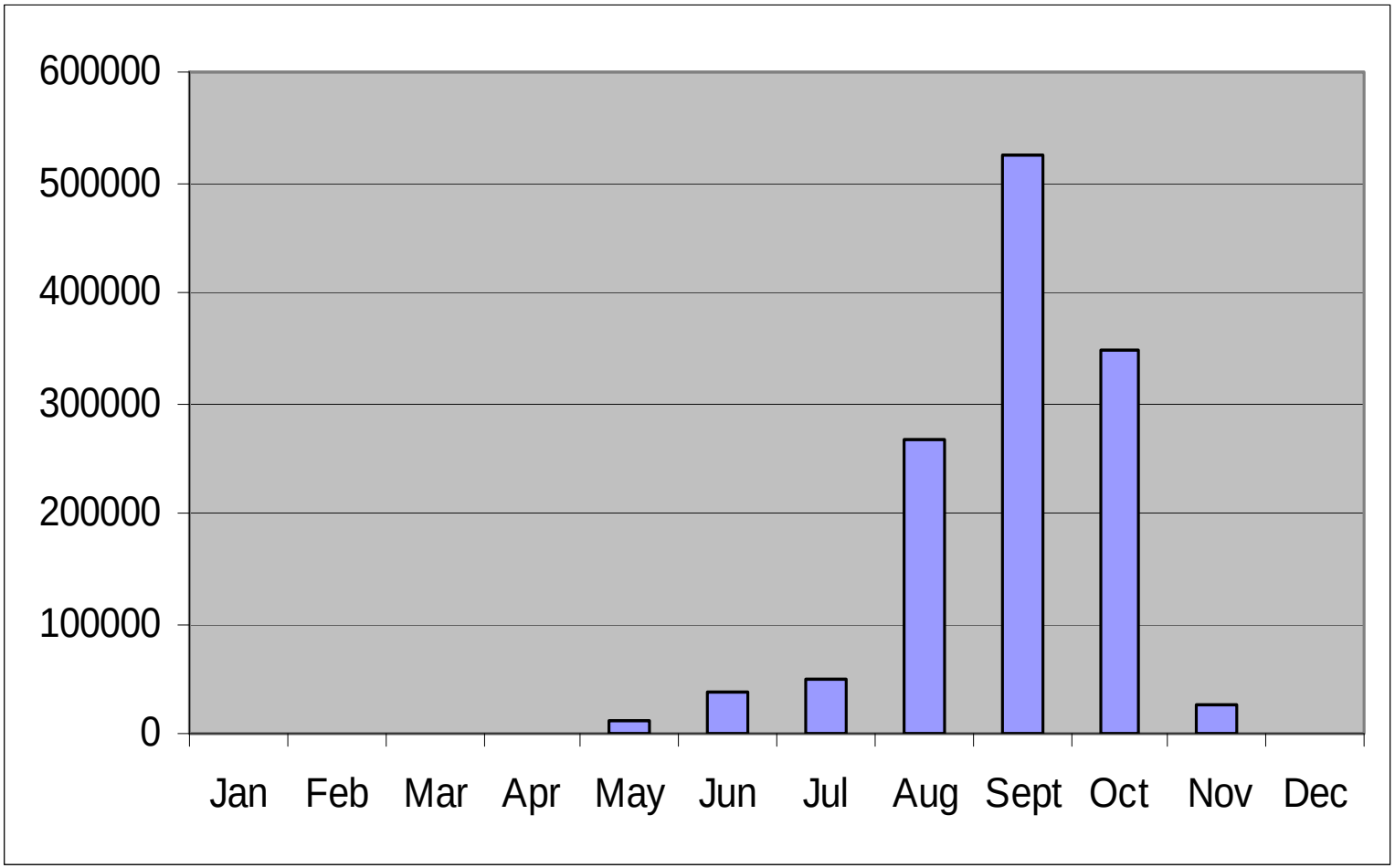
$$\text{Exp}\{\text{Arith. Mean Ln} + Z_{(0.95)} * \text{Std. Dev. Ln}\}$$

Where: Arith. Mean Ln = the arithmetic mean of the natural logs of the values

$Z_{(0.95)}$ = the standard normal deviate such that 95% of the distribution is less than that value

Std. Dev. Ln = the standard deviation of the natural logs of the values

Annual Use of Methyl Bromide as a Pre-Plant Soil Fumigant in Monterey County (2000-2004)



Calculation of Absorbed Dose

Absorbed Dose (AD_i) average:

$AD_i = C_{mi} \times IR \times (1-PF) \times AF$

Where: C_{mi} is the concentration of MI (µg/L)
IR is the inhalation rate (L/hr) (833 L/hr for adults)
PF is the protection factor for ppe (90% in this case)
AF is the absorption/retention factor (100%)

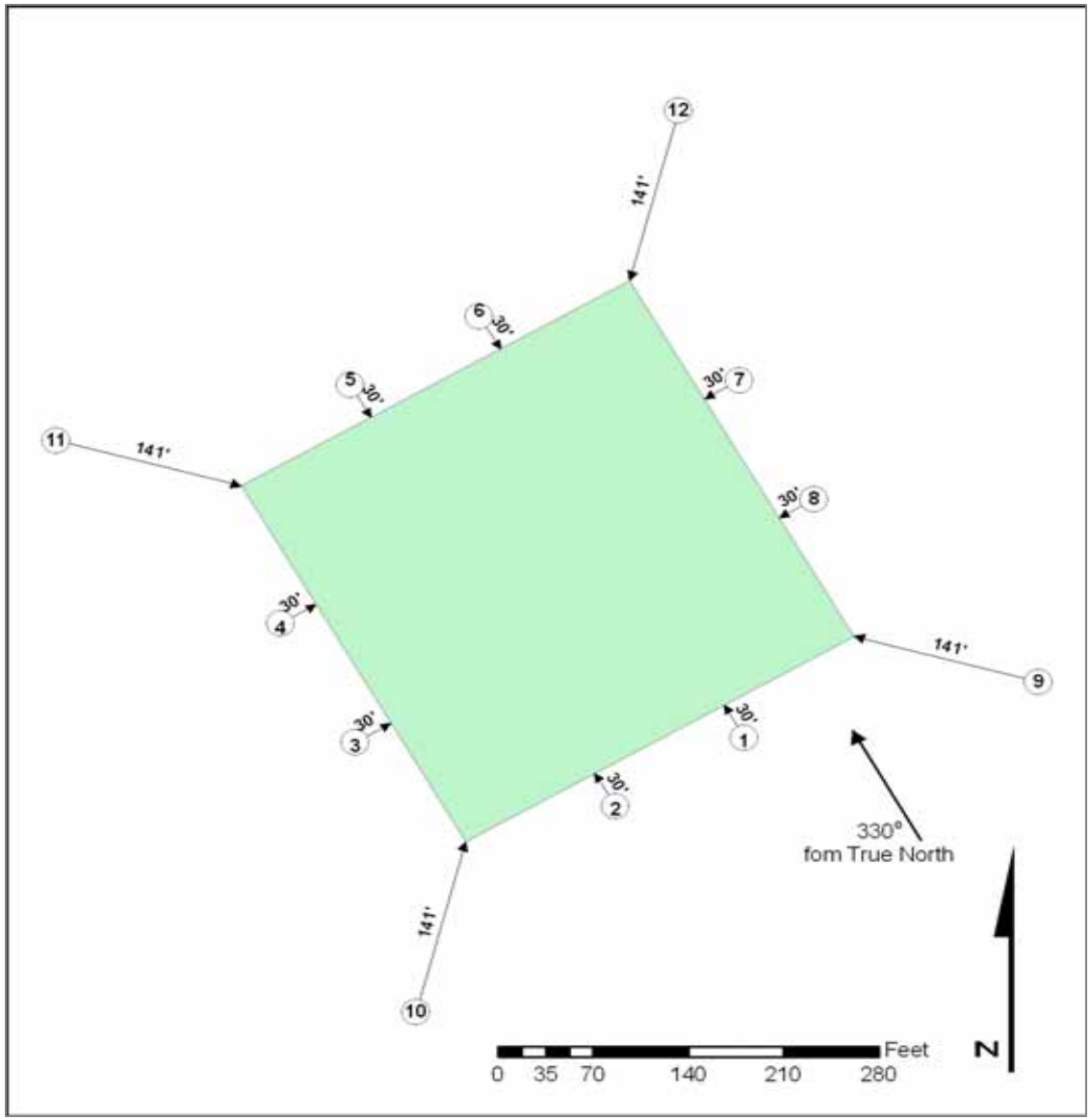
Absorbed Daily Dosage (ADD) average:

$ADD = AD_i \times$ daily duration (hr/day)/body weight

Short-term, Intermediate-term, and Long-term Exposures to Methyl Iodide for Handlers and Re-entry Workers

Work Task	N	ADD ug/kg-day	SADD ug/kg-day	AADD ug/kg-day	LADD ug/kg-day
Drip Irrig. Applicators	6	1.1 (0.003 ppm)	0.61 (0.001 ppm)	0.15 (0.0003 ppm)	0.08 (0.0002 ppm)
Hole Puncher	3	8.3 (0.015 ppm)	3.6 (0.01 ppm)	0.9 (0.002 ppm)	0.5 (0.0008 ppm)
Planters	6	2.3 (0.004 ppm)	0.6 (0.001 ppm)	0.1 (0.0003 ppm)	0.05 (0.0002 pppm)
Shallow Shank Applicators	4	120.4 (0.27 ppm)	26.2 (0.06 ppm)	6.6 (0.015 ppm)	3.5 (0.008 ppm)
Shovelmen, Shovelers	6	37.4 (0.08 ppm)	10.2 (0.02 ppm)	2.6 (0.005 ppm)	1.4 (0.003 ppm)
Tarp Monitors	4	141.7 (0.3 ppm)	24.8 (0.04 ppm)	6.2 (0.01 ppm)	3.3 (0.005 ppm)
Hole Punchers, Tarp Cutters and Removers	5	44.1 (0.08 ppm)	11.6 (0.03 ppm)	2.9 (0.008 ppm)	1.5 (0.004 ppm)
Planters	5	3.6 (0.006 ppm)	1.9 (0.004 ppm)	0.5 (0.001 ppm)	0.3 (0.0005 ppm)

Estimation of Bystander Exposures to Methyl Iodide



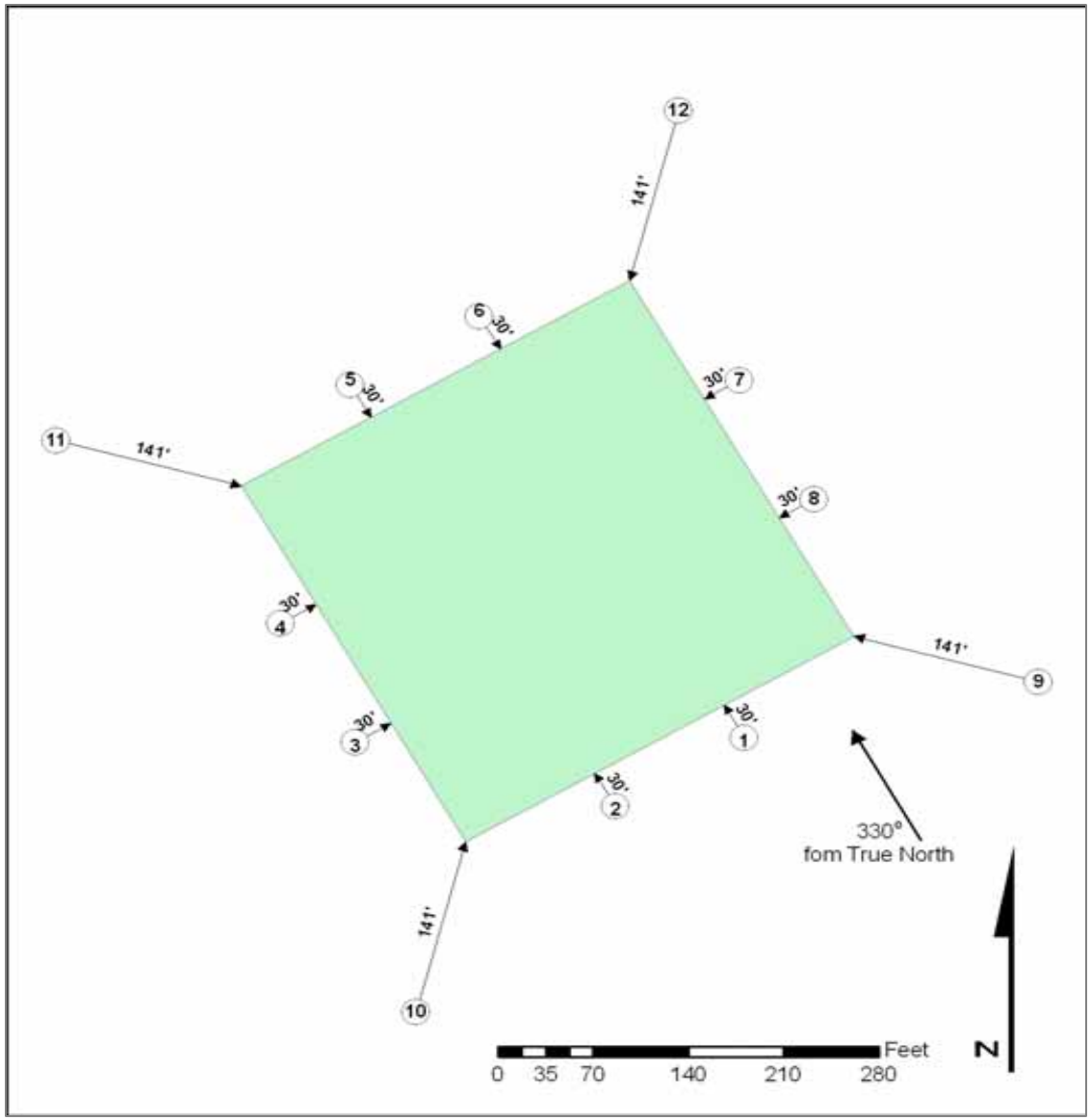
Air Dispersion Modeling

- Air dispersion models link emissions from one or more sources to ambient chemical concentrations
- Gaussian Plume Model
- Gaussian Plume Model inputs:
  - **Field volatility** (**emission rate** or **flux**)
  - Dimensions and orientation of treated field, distance from field, urban or rural dispersion pattern
  - Temperature, wind speed, atmospheric stability
- Gaussian Plume Model Screening mode:
  - Model predicts the reasonable worst case **downwind** ground level concentrations that can occur off-site over a wide range of meteorological conditions

Estimation of Bystander Exposures to Methyl Iodide

Field volatility estimates:

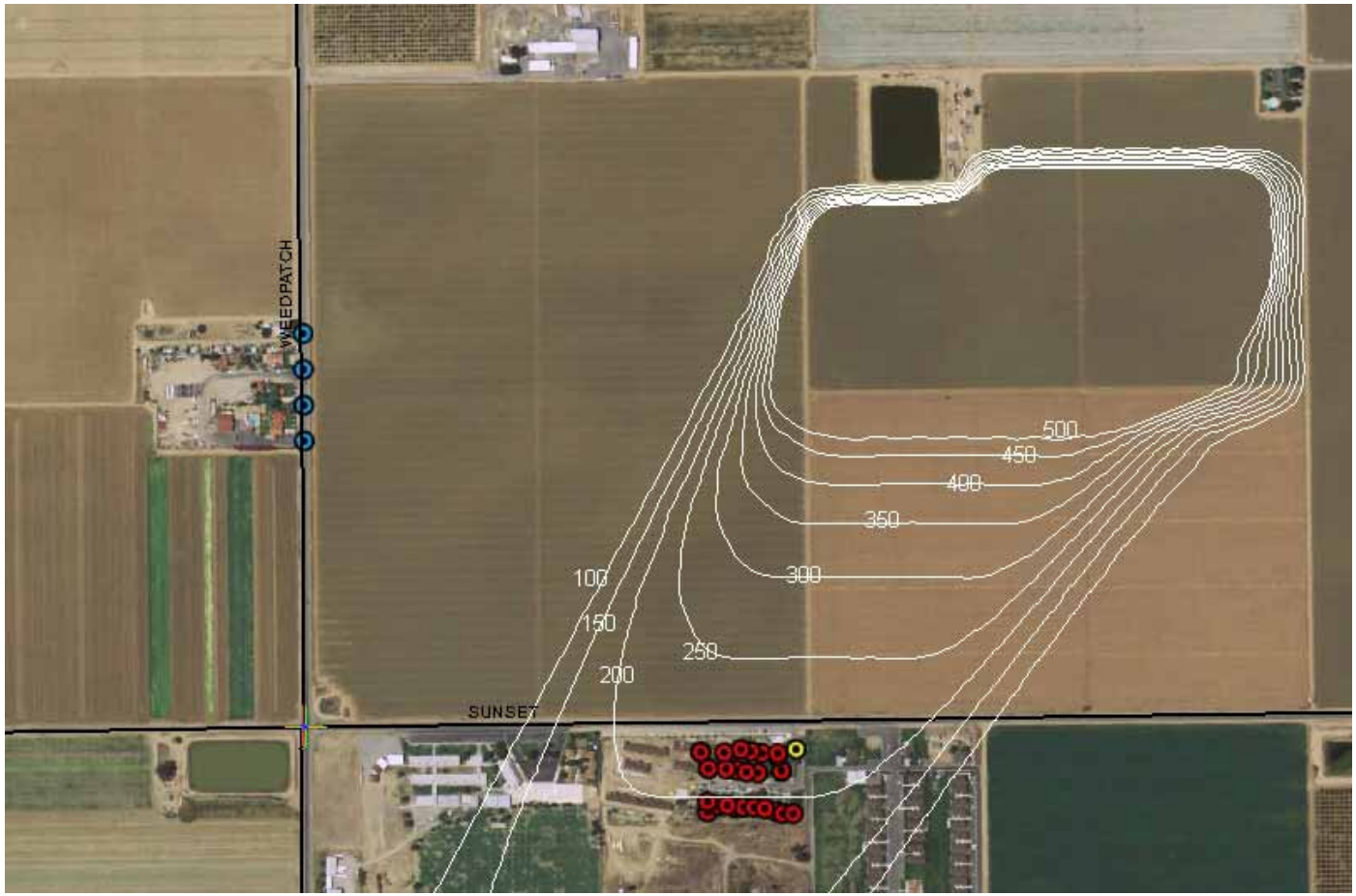
1) Back Calculation
2) Direct Flux



Off-Site Movement: Plume

Plume movement away from the field is affected by wind speed and direction

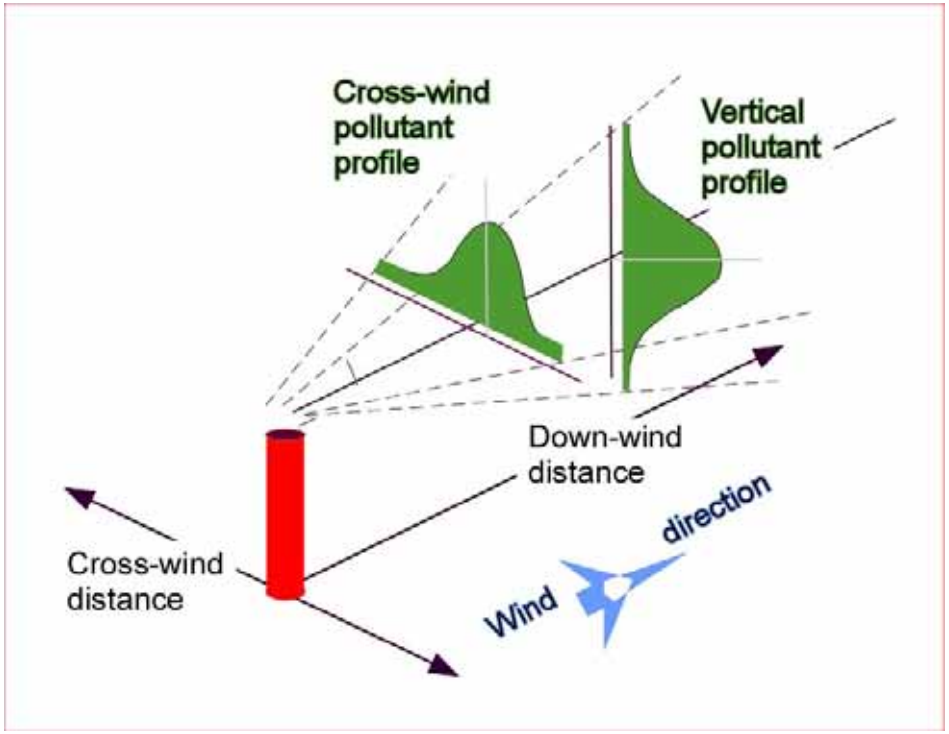
Off-Site Movement: Plume



The fumigant volatilizes, mixes with air and moves downwind.

DPR Uses the ISCST3 Model

Industrial Source Complex—Short Term, Version 3



(Figure from Univ of Colorado)

Features of ISCST3 model

- **Steady-state:** conditions do not change within a unit of time (e.g., 1 hour)
- **Gaussian plume:** chemical concentrations peak at center of plume, taper toward edges
  - Calculate concentrations along plume centerline

Computer Modeling

- Industrial Source Complex Short Term (ISCST3)
- Primary model used by DPR since 1992
  - DPR modeling of methyl bromide was review by the National Academy of Sciences
- Gaussian plume model developed by U.S. EPA Office of Air

$$C = F \times M$$

C = concentration (ug/m^3)

F = flux (ug/m^2s)

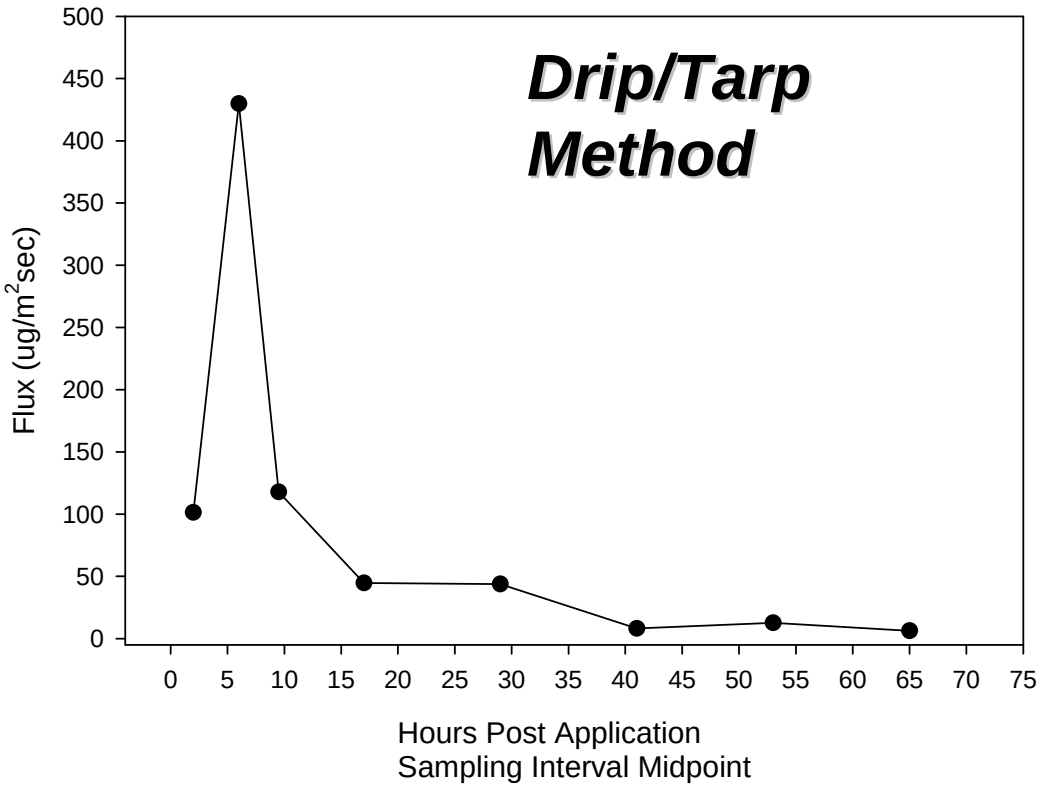
M = Function of x,y,z,meteorology (s/m)

Computer Modeling

- Screening methods produce reasonable worst case air concentration estimates
- The averaging time of the air concentration is directly related to the averaging time that produced the flux estimate
- The meteorological data is considered the predominant condition for that averaging time
  - Screening meteorological conditions can and do occur in the environment
  - The wind direction is interpreted as the predominant (average) direction for the averaging time

Example Flux Profile

Sampling intervals for the first 3 days following application



Estimating Seasonal Concentrations

- Based the flux profile, the average 24-hour flux was calculated over 2 weeks
- The average daily air concentration for the 2 week period was calculated using the average 24-hour flux
- A time scaling factor of 0.48 was use to adjust the average daily air concentration to a 2 week average air concentration.
  - The time scaling factor accounts for the effect of meteorological variation on air concentrations over the longer averaging time

Estimated absorbed dosages of methyl iodide for bystander workers exposed to daily and seasonal air concentrations at the 152 m buffer zone from different types of application sites.

Application Method	8-hour ADD ug/kg-day	SADD ug/kg-day
Drip Irrigation	882 (1.6 ppm)	19 (0.01 ppm)
Raised-bed Shank	325 (0.6 ppm)	19 (0.01 ppm)
Flat-field Shank	538 (1.0 ppm)	19 (0.01 ppm)

Estimated absorbed dosages of methyl iodide for bystander adults exposed to daily and seasonal air concentrations at the 152 m buffer zone from different types of application sites.

Application Method	24-hour ADD ug/kg-day	SADD ug/kg-day
Drip Irrigation	473 (0.3 ppm)	19 (0.01 ppm)
Raised-bed Shank	278 (0.2 ppm)	19 (0.01 ppm)
Flat-field Shank	334 (0.2 ppm)	19 (0.01 ppm)

Estimated absorbed dosages of methyl iodide for bystander children (3-5 yrs) exposed to daily and seasonal air concentrations at the 152 m buffer zone from different types of application sites.

Application Method	24-hour ADD ug/kg-day	SADD ug/kg-day
Drip Irrigation	793 (0.3 ppm)	33 (0.01 ppm)
Raised-bed Shank	467 (0.2 ppm)	33 (0.01 ppm)
Flat-field Shank	560 (0.2 ppm)	33 (0.01 ppm)

Estimated absorbed dosages of methyl iodide for bystander infants (< 1 yr) exposed to daily and seasonal air concentrations at the 152 m buffer zone from different types of application sites.

Application Method	24-hour ADD ug/kg-day	SADD ug/kg-day
Drip Irrigation	969 (0.3 ppm)	40 (0.01 ppm)
Raised-bed Shank	570 (0.2 ppm)	40 (0.01 ppm)
Flat-field Shank	684 (0.2 ppm)	40 (0.01 ppm)

Estimated Daily, Seasonal, and Annual Absorbed Dosages of MI for Resident Bystanders Near a 40 Acre Treated Field

Individual	24-hour ADD µg/kg-day	SADD µg/kg-day	AADD µg/kg-day
Resident Adult	473 (0.3 ppm)	19 (0.01 ppm)	5 (0.003 ppm)
Child (3-5 yrs)	793 (0.3 ppm)	33 (0.01 ppm)	8 (0.003 ppm)
Infants (<1 yr)	969 (0.3 ppm)	40 (0.01 ppm)	10 (0.003 ppm)