A CHARACTERIZATION OF SEQUENTIAL AERIAL MALATHION APPLICATIONS IN THE SANTA CLARA VALLEY OF CALIFORNIA, 1981

ENVIRONMENTAL HAZARDS ASSESSMENT PROGRAM

State of California
Department of Food and Agriculture
Division of Pest Management, Environmental Protection & Worker Safety
Unit of Environmental Monitoring & Pest Management
1220 N Street, Sacramento, California 95814

EH 82-01

A CHARACTERIZATION OF SEQUENTIAL AERIAL MALATHION APPLICATIONS IN THE SANTA CLARA VALLEY OF CALIFORNIA, 1981

by

R.J. Oshima, L.A. Neher, T.M. Mischke,
D.J. Weaver, and O.S. Leifson

Environmental Hazards Assessment Program
California Department of Food & Agriculture

April 1982

Field Monitoring: L.A. Neher, R. Segawa, R. Sava, M.I. Carmean, D. Duncan, B. Johnson, S. Simpson, F. Zalkin, J.M. Lee, T. Schmer, E. Rey, L. O'Connell, H. Fong, A. de Castro, S. Barbee, D. Cook

Sampling Methods: T.M. Mischke, J.R. Franz

Chemical Analysis: CDFA Chemistry Laboratory

Programming: M. Poe[1], T. Casey[1], T. Arnold[1]

Data Processing: C. Au, S. Kilgore, L. Bezark, J. Maguire

Statistics: R. Gallavan[1]

Graphics: M. Poe[1], D. Kaseda[1]

1) Statewide Air Pollution Research Center
U.C. Riverside

ABSTRACT

The aerial application of baited malathion (2.4 fl oz 91% malathion, with 9.6 fl oz Staleys protein bait per acre) was utilized in the Mediterranean Fruit Fly eradication program in the Santa Clara Valley of California in 1981. Approximately 250 square miles of essentially urban area was included in an intensive environmental monitoring project which was conducted over a six week period beginning July 14, 1981 and ending August 30, 1981. The objective of this project was to quantitatively characterize a sequence of six weekly aerial sprays on the environment. The sequence of six aerial applications produced an average mass fallout deposition of 1,385 $\mu g/ft^2$ malathion composed of droplets between 35 and 1,750 μ in diameter with a mean volumetric diameter between 200 and 300 μ. Results for each spray week were highly variable when considered individually but noticeably more homogeneous when the cumulative six spray week period was considered. The mass fallout deposition in areas flagged for exclusion from spraying was significant despite efforts to isolate them. Air monitoring of malathion and malaoxon indicated that gas phase levels never exceeded 1 $\mu g/m^3$ malathion and 0.1 $\mu g/m^3$ malaoxon, well within the parts per trillion range. Outside air concentrations were generally higher than indoor values. Water concentrations were related to mass fallout deposition and averaged less than 10 ppb. Elevated levels of malathion in individual water samples appeared to be restricted to bodies of water with high surface area to volume ratios such as reflecting ponds, golf course water hazards and shallow stagnant pools in dry stream beds. Rainfall runoff extracted malathion and malaoxon from large concrete and asphalt surfaces in urban areas and channeled high concentrations into streams, resulting in concentrations as high as 500 ppb. The same rain

runoff characteristics were documented for a natural riparian habitat but the water concentrations of malathion were much lower. Seventy-six percent of the application rate could be accounted for as mass fallout deposition, an unusually efficient application considering the 300 ft release altitude.

ACKNOWLEDGMENTS

We are indebted to Dr. Norman Akesson, Department of Agricultural Engineering, University of California, Davis, California, for his efforts in obtaining spread factors for baited malathion, analyzing droplet sizing cards and summarizing the droplet data used in this report.

Special thanks is extended to Maria Martinez, Michelle Vadino, Merry Cardoza, and Terry Basurto, for typing and compiling the final report.

We are also indebted to B. Winters and C. Hobarth who constructed and packaged all the monitoring samples for use in the field and to Marie Balboni whose air taxi service was invaluable.

Thanks also extended to J.N. Pitts and the staff of the Statewide Air Pollution Research Center, University of California, Riverside, for their support.

DISCLAIMER

The mention of commercial products, their source or their use in connection with material reported herein is not to be construed as either an actual or implied endorsement of such product.

TABLE OF CONTENTS

		Page
Abstract		2
Acknowledgements and Disclaimer		4
Table of Contents		5
List of Figures		7
List of Tables		8
Conclusions		10
Recommendations		11
1.	Introduction	12
2.	Study Location and Description	13
3.	General Materials and Methods	15
4.	Formulation and Characteristics of Application	19
5.	Characterization of Aircraft Swaths	19
6.	Environmental Monitoring of Aerial Sprays: Mass Fallout	23
7.	Environmental Monitoring of Aerial Sprays: Air Monitoring	52
8.	Environmental Monitoring of Aerial Sprays: Water Monitoring	57
9.	Discussion	78
10.	References	83
Appendix I	Study Protocol	84
Appendix II	Chain of Custody Form Used for Sample Security	93
Appendix III	Tables Summarizing Air Concentrations of Malathion and Malaoxon Collected Inside and Outside of Residences for Each Spray Week and the Average of 6 Spray Weeks	95

Appendix IV Tables Summarizing Air Concentrations of Malaoxon in Air Sample from Hospitals and Nursing Homes during Each Spray Week and the Average of 6 Spray Weeks 104

Appendix V Tables Summarizing Air Concentrations of Malathion in Air Samples from Hospitals and Nursing Homes during Each Spray Week and the Average of 6 Spray Weeks 113

Appendix VI Tables Summarizing Concentrations of Malathion and Malaoxon in Water Samples from Each Spray Week and the Average of 6 Spray Weeks 122

LIST OF FIGURES

		Page
Figure 1.	Geographic Location of the Study Cells	14
Figure 2.	Cell Identification Key	16
Figure 3.	Average Malathion Deposition per Geographical Cell for Spray Weeks 1 and 2	29
Figure 4.	Average Malathion Deposition per Geographical Cell for Spray Weeks 3 and 4	30
Figure 5.	Average Malathion Deposition per Geographical Cell for Spray Weeks 5 and 6	31
Figure 6.	Average Malathion Deposition per Geographical Cell for Spray Weeks 1 through 6	33
Figure 7.	Deposition of Malathion from Flagged Locations; Spray Weeks 1 and 2	34
Figure 8.	Deposition of Malathion from Flagged Locations; Spray Weeks 3 and 4	35
Figure 9.	Deposition of Malathion from Flagged Locations; Spray Weeks 5 and 6	36
Figure 10.	Individual Fallout Deposition for Spray Week 1, Spray Week 2, Spray Week 3, Spray Week 4, Spray Week 5 and Spray Week 6	38
Figure 11.	Functions Relating the Proportion of Total Number of Sampled Particles Equal to or Less Than a Volumetric Mean Diameter	40
Figure 12.	Air Concentrations of Malathion from Convalescent/ Nursing Homes	58
Figure 13.	Air Concentrations of Malathion from Private Residences	59
Figure 14.	Air Concentrations of Malaoxon from Convalescent/ Nursing Homes	60
Figure 15.	Air Concentrations of Malaoxon from Private Residences	61
Figure 16.	Air Concentrations of Malathion from Hospitals	63
Figure 17.	Air Concentrations of Malaoxon from Hospitals	64
Figure 18.	Water concentrations of Malathion in Reservoirs and swimming pools	70
Figure 19.	Water concentrations of Malathion for water bodies outside the spray zone	72

LIST OF TABLES

		Page
Table 1.	t Tests of Duplicate Samples	18
Table 2.	Characterization of Helicopter Swath	22
Table 3.	Characterization of Fixed-Wing Aircraft Swath	24
Table 4.	Droplet Size Characteristics of Aerially Applied Baited Malathion During Spray Week 1	41
Table 5.	Droplet Size Characteristics of Aerially Applied Baited Malathion During Spray Week 2	41
Table 6.	Droplet Size Characteristics of Aerially Applied Baited Malathion During Spray Week 3	42
Table 7.	Droplet Size Characteristics of Aerially Applied Baited Malathion During Spray Week 4	42
Table 8.	Droplet Size Characteristics of Aerially Applied Baited Malathion During Spray Week 5	43
Table 9.	Droplet Size Characteristics of Aerially Applied Baited Malathion During Spray Week 6	43
Table 10.	Droplet Size Characteristics of Aerially Applied Baited Malathion; Spray Weeks 1 - 6	44
Table 11.	Droplet Size Characteristics of Aerially Applied Baited Malathion from Flagged Sites; Spray Week 1	45
Table 12.	Droplet Size Characteristics of Aerially Applied Baited Malathion from Flagged Sites; Spray Week 2	45
Table 13.	Droplet Size Characteristics of Aerially Applied Baited Malathion from Flagged Sites; Spray Week 3	46
Table 14.	Droplet Size Characteristics of Aerially Applied Baited Malathion from Flagged Sites; Spray Week 4	46
Table 15.	Droplet Size Characteristics of Aerially Applied Baited Malathion from Flagged Sites; Spray Week 5	47
Table 16.	Droplet Size Characteristics of Aerially Applied Baited Malathion from Flagged Sites; Spray Week 6	47
Table 17.	Droplet Size Characteristics of Aerially Applied Baited Malathion from Flagged Sites; Spray Weeks 1 - 6	48

List of Tables (Con't)

		Page
Table 18.	Mass Deposition Comparisons Within and Among Geographic Cells	51
Table 19.	Air Monitoring Instrument Oxidation Efficiencies	56
Table 20.	Average Malathion and Malaoxon Air Monitoring Results from Nursing/Convalescent Homes for 6 Spray Weeks	65
Table 21.	Average Malathion and Malaoxon Air Monitoring Results for Private Residences for 6 Spray Weeks	66
Table 22.	Average Malathion and Malaoxon Air Monitoring Results for Hospitals for 6 Spray Weeks	67
Table 23.	Malathion Concentrations from Runoff Water in the Santa Clara Valley Storm Drain System	74
Table 24.	Malathion and Malaoxon Levels from Runoff Water in the Santa Clara Storm Drain System	75
Table 25.	Pescadero Creek Water Monitoring	77

CONCLUSIONS

Results of environmental monitoring of baited malathion sprays over a six week period were generally predictable. Mass fallout deposition, although variable for individual spray weeks, was relatively uniform on exposed surfaces at the end of six spray weeks. The population of mass fallout droplets was characterized by large sizes with a volumetric mean diameter between 200 to 300 μ and a range of 35 to 1,750 μ. The average deposition efficiency of the monitored six spray weeks was 76%. Malathion and its principal oxidation product, malaoxon, were detected in low concentrations in both water (ppb) and air (ppt) throughout the monitoring period. Concentrations of pesticide in water were related to mass fallout deposition. Air concentrations were characterized as a low level saturation condition (ppt) with elevated periods correlated with individual sprays.

Excessive levels of malathion and malaoxon were found only in water from rain runoff. The storm drain system in the Santa Clara Valley collected runoff and deposited water with malathion concentrations as high as 583 ppb into existing streams. Malathion and malaoxon levels did not accumulate in air, water, or on exposed surfaces during the six spray week period. Peak levels associated with individual sprays always degraded to background concentrations which remained consistent throughout the six spray period.

The identification of small geographical areas to be excluded from spraying (flagging) was only partially effective. Some flagged locations in each spray week were inadvertently subjected to direct spray. The majority of flagged locations did, however, receive lower deposits of mass fallout than the spray area.

RECOMMENDATIONS

1. It is recommended that aerial applications of baited malathion be re-scheduled or eliminated during periods when rains are forecast. The extraction and removal of high levels of malathion and malaoxon by rain water reduces the eradication potential of the baited spray and creates justifiable concern for aquatic biota in both fresh and salt water environments.
2. It is recommended that subsequent environmental monitoring be limited to spot sampling to insure that pesticide levels remain within the documented ranges since the results of this intensive study are conclusive in documenting the character of sequential aerial sprays. Large scale monitoring would occur only if a major change in pesticide, application rate, or method of application were made.

1. INTRODUCTION

The aerial application of baited malathion has been used to eradicate infestations of Mediterranean Fruit Fly in Florida (1956-1957, 1962-1963) and Texas (1966), but the scientific literature contains little information describing the environmental impact of the spray. Most published articles contain results of surveys designed to evaluate the effectiveness of eradication efforts and do little to address the impact of the spray on the environment. Additionally, the literature does not contain the quantitative characterization of the sprays that is needed to evaluate potential effects on humans or non-target species. These inadequacies represent serious gaps in the literature and prevent attempts to evaluate the effects of long-term exposure to a series of low-dose malathion exposures.

A Mediterranean Fruit Fly infestation was detected in Santa Clara County, California, in June, 1980. This infestation persisted despite ground-oriented eradication attempts that extended into 1981 when increased adult trapping and larval finds dictated the use of aerial sprays. The Environmental Hazards Assessment Program (EHAP), California Department of Food and Agriculture (CDFA), was asked to develop an environmental monitoring protocol (Appendix I) to define the impact of multiple aerial applications of baited malathion on an urban environment. The resultant data base was to be used in the evaluation of anticipated human exposure and impact studies on non-target species.

Initial efforts to define the composition of the study area in terms of residences, hospitals, schools, natural and man-made water bodies, and other areas of concern were implemented in March, 1981. Sampling design, spatial distribution of sample locations, site inspection, obtaining permission to utilize

private properties, and identification of biologically sensitive locations required an extensive expenditure of resources and time in order to be prepared for a potential aerial spray. The initial groundwork was completed by June, 1981. Resources available to the program restricted the in-depth, intensive monitoring to a six spray period followed by light statistical sampling of subsequent sprays to insure that they conformed to the characteristics determined during the intensive sampling period. Some special monitoring projects extended beyond the six spray period.

The decision to utilize aerial spraying was made and spray 1 was initiated on July 14, 1981. Sprays 2 through 6 were applied during the following 5 weeks terminating August 30, 1981. This report characterizes the aerial spray which was applied on the mostly urban environment in the eradication zone.

2. STUDY LOCATION AND DESCRIPTION

The geographical boundaries of the study location, to a great extent, lie within the confines of the Santa Clara Valley of California directly adjacent to the South San Francisco Bay. The boundaries encompassed all or parts of the following communities: Palo Alto, Los Altos, Mountain View, Sunnyvale, Cupertino, Santa Clara, Saratoga, Campbell, San Jose, Milpitas, and Los Gatos. The total area was approximately 250 square miles and contained an estimated 403,700 residences, 476 public schools, and 78 hospitals and convalescent care facilities.

Prior to aerial applications, the study area was subdivided into 45-2 mile square cells in order to insure adequate spatial distribution of sampling sites (Figure 1). The number and size of the cells was derived from an analysis of program resources. The eradication area was later expanded requiring additional

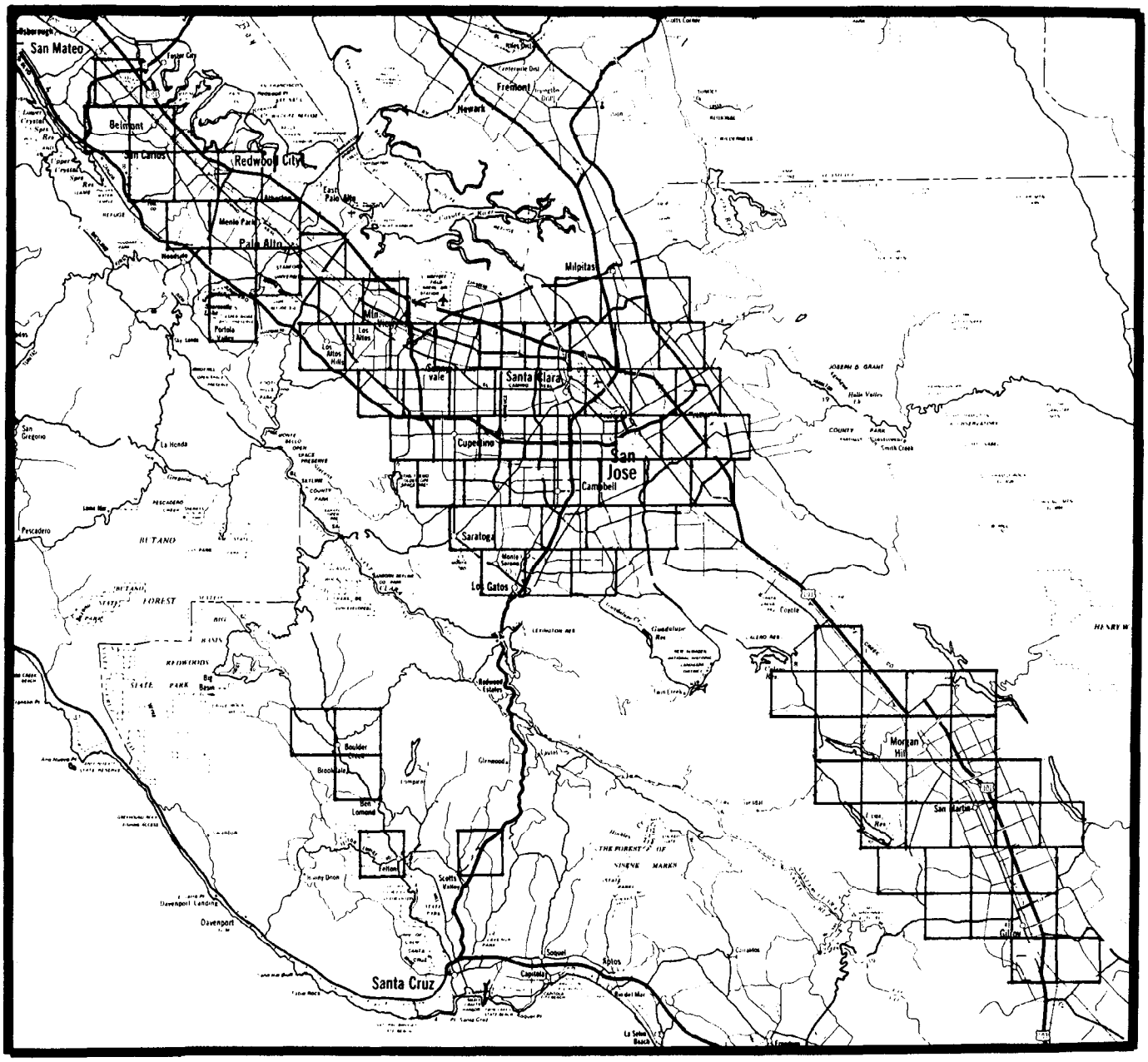

Figure 1. Geographic location of the study cells established prior to and during the six week aerial spray period.

cells of the same dimensions for a total of 89 at the end of the sixth spray. The additional cells extended north into San Mateo County on the western edge of the bay, south into San Benito County and west to include the Portola Valley. The lack of organization in the cell identification key (Figure 2) reflects the sporadic expansion of the eradication effort. Cells 90-94 were only used for special projects and were not included in the intensive monitoring.

3. GENERAL MATERIALS AND METHODS

This section contains the general description of materials and methods utilized throughout the project. Materials and methods pertinent to specific phases of the project are presented in those sections categorized by the type of monitoring conducted. For example, the Air Monitoring Section contains the specific materials and methods utilized during that phase.

3.1 Sample Security

Each sample generated by EHAP was accompanied by a chain of custody form documenting the sequence of transfers from sample generation to final chemical analysis (Appendix II). Every individual who handled the sample was required to sign the form, acknowledging receipt and relinquishment of the sample and dating each transfer. This form was also designed for recording data to be keypunched into a computer. Location codes, sampling dates, sample description, specific sampling times and results were recorded.

3.2 Chemical Analysis

All chemical analyses were performed by the Chemistry Laboratory Services Unit of the California Department of Food and Agriculture at the Unit's

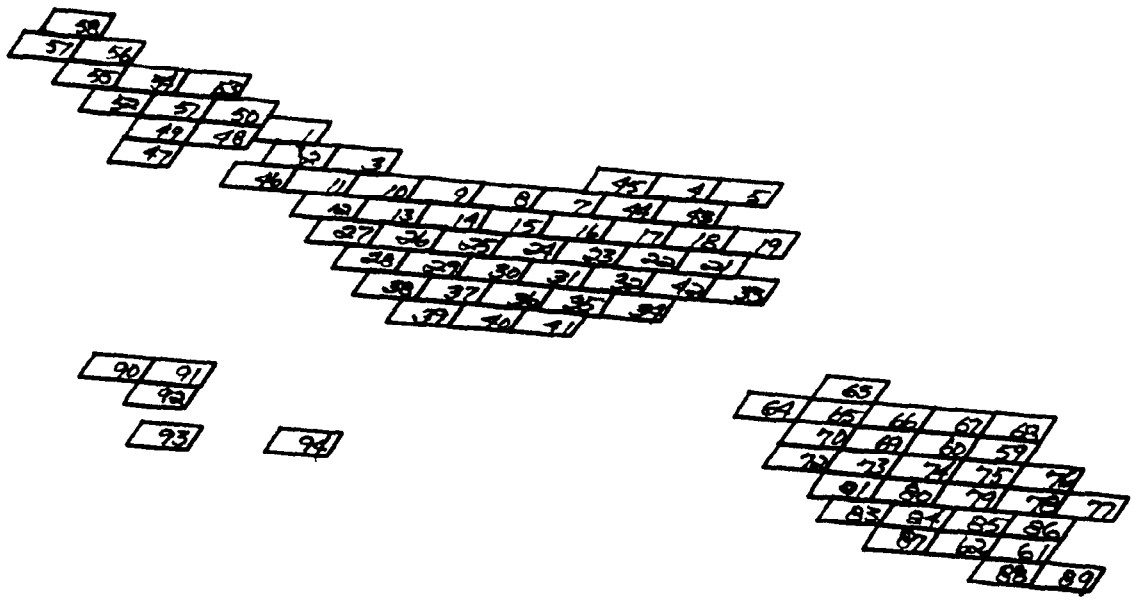

Figure 2. Cell identification key for environmental monitoring locations. Two cells presented in Figure 1 were not included in the eradication zone and were not assigned a numerical designation.

main laboratory in Sacramento.

Extractions were made with "Pesticide Grade" solvents. Analytical methods using gas chromatography (GC) were validated using a Finnigan 4000 gas chromatograph/mass spectrometer (GC/MS). Gas chromatography analyses which appeared questionable were repeated either on the Finnigan 4000 GC/MS or on another GC using an analytical column and detector different from the first analysis.

3.3 Quality Control

In addition to the above, duplicates of selected samples were sent to a private laboratory (California Analytical Laboratory, Inc.) for comparative analysis. These split samples were analyzed using comparative analytical methods and included mass spectrometry as well as gas chromatography. An analysis of the split samples analyzed by both laboratories is presented in Table 1. The two-tailed, paired t test indicated that no significant differences occurred between laboratories. It should be noted however, that the comparisons test mean differences within sampling media and do not test individial sample differences between laboratories.

3.4 Data Handling

Three Apple II microcomputer systems including disk drives, CRT monitors, acoustical couplers and printers were utilized for data entry and transmission. One system was located at each of three locations (Los Gatos, Sacramento, and Riverside, California). The computer files were initially generated in Los Gatos when field samples were collected and checked in. These data files were then transmitted by telephone to Sacramento where the results from the State Chemistry Laboratory were entered. The data files were edited and again transmitted over the telephone lines to Riverside where the files were trans-

Table 1. Results of two-tailed, paired t tests of duplicate samples analyzed by both CDFA and CAL labs

	Sample size[1]	ΔMean[2]	Standard deviation[2]	Standard error[2]	t calc[3]	t crit. (0.05)
Malathion						
Mass deposition	8	-132.6 µg	236.0	83.4	-1.59 ns[4]	2.37
Air samples	4	0.25 µg	0.53	0.26	0.93 ns	3.18
Water samples	30	-0.23 ppb	12.2	2.22	-0.10 ns	2.05
Water samples	26[5]	-0.72 ppb	5.25	1.03	-0.70 ns	2.06
Malaoxon						
Water samples	3	-0.20 ppb	0.41	0.23	-0.87 ns	4.30

1. Number of pairs
2. Based on pair differences
3. Test for mean separation
4. ns = not significant
5. Rerun after deletion of the differences -30, -22.9, and 37.8 (maximum differences)

ferred to a Prime 400 interactive computer for analysis. Those samples identified for a 24 hr turnaround were compiled and analyzed, and results were transmitted over the telephone lines to Los Gatos for dissemination.

The microcomputer system was not the ideal network for the monitoring project because of limitations in RAM and disk storage. The system was utilized because of the minimum time requirements necessary to establish a functional network. The talents of an innovative programming staff helped overcome the numerous problems involved with handling large data sets.

Software was developed by programmers from the Statewide Air Pollution Research Center, University of California, Riverside. A series of programs for data entry, editing, and communication were developed especially for the monitoring project. Additionally, many utility and calculation programs were also developed to provide the means to produce summaries for the samples requiring a 24 hr completion cycle.

4. FORMULATION AND CHARACTERISTICS OF APPLICATION

The actual aerial applications applied by the Medfly Eradication Program consisted of 2.4 fluid oz technical grade malathion (91% active ingredient) mixed with 9.6 fluid oz of Staleys Protein Bait. This mixture was applied by helicopter at an altitude of 300 ft. early in the eradication program. A combination of helicopters and fixed wing aircraft were used after the infestation had expanded beyond the confines of the Santa Clara Valley.

5. CHARACTERIZATION OF AIRCRAFT SWATHS

5.1 Materials and Methods

The calibration of aircraft swaths was arranged during the actual

eradication period. Airport locations were agreed upon and single flights were planned for 2 days with minimal wind during periods when aircraft were in use for eradication sprays. Good weather, the availability of the aircraft and the availability of environmental monitoring staff proved to be a difficult combination to schedule and the swath calibrations were not conducted until the eradication effort was well underway.

Two airport locations with a large expanse of available flat terrain were obtained. A series of monitoring locations consisting of mass fallout sheets and particle sizing cards were established in a line perpendicular to the aircraft flightline. An observer on the ground coordinated with the aircraft pilot to obtain a single pass over the line of monitoring locations at a 300 ft altitude with spray apparatus fully operational. Samples were retrieved 0.5 hours after the aircraft flight, appropriately packed and transported to the State Chemistry Laboratory in Sacramento, and U.C. Davis for analyses. Detailed descriptions of the materials and methods used for each sample type are presented in the appropriate sections of this report.

The helicopter used in the swath characterization was a Bell 206 equipped with six, 7.5 x 0.25 inch flood jet nozzles and radar elevation instrumentation. The spray pass was scheduled on a return flight to the airport at 0130 hrs and was flown at an air speed of 70 to 75 knots at an altitude of 300 ft. Boom pressure was adjusted to 20 p.s.i., identical to the pressure setting used in the eradication effort.

A DC-4 aircraft equipped with four nozzles constructed from 0.25 inch

copper tubing flattened into an eliptical shape was used for the fixed-wing test. The spray pass was scheduled during a departure from the airport at 0720 hrs and was flown at an air speed of 145 knots at an altitude of 300 ft. Samples were taken 650 ft. downwind of and perpendicular to the aircraft flightline. A boom pressure of 20 p.s.i. was again utilized.

5.2 Results

The characteristics of aerial swaths from the helicopter and DC-4 were very similar in most respects. The ranges of mass fallout (160-3,600 $\mu g/ft^2$ for the helicopter and 208-1,450 $\mu g/ft^2$ for the DC-4) overlapped sufficiently considering the differences in aircraft, air speed, spray configurations, locations, and meteorology. Additionally, droplet size ranges (509 to 127 μ mean droplet diameter helicopter and 422 to 145 μ DC-4) and droplet deposition (730 to 313 droplets/ft^2 helicopter and 886 to 83 droplets/ft^2 DC-4) were comparable.

If the desired deposition rate stated by the Section 18 Emergency Use Permit (2.4 fl oz 91% malathion/acre or 1,836 $\mu g/ft^2$) is compared to actual results, only the mass fallout directly beneath the helicopter flightline reached or exceeded the desired value (Table 2). The effective swath width using this criterion would be less than 75 ft for a single helicopter. The mass fallout for the DC-4 swath never approached the desired deposition rate.

5.2.1 Helicopter Swath Characterization

The helicopter swath was characterized by a rapid decrease in mass fallout downwind from the aircraft flightline ranging from a maximum of 3,600 $\mu g/ft^2$ on the flightline to a low value of 160 $\mu g/ft^2$, 300 ft downwind (Table 2). Droplet size decreased with downwind distance from a maximum of 509 μ

Table 2. Characterization of Helicopter Swath[1] Using Baited Malathion[2]

Sampling location[3]	Mass fallout ($\mu g/ft^2$)	Droplet count ($\#/ft^2$)	Mean droplet diameter (μ)
75 ft upwind	0	0	0
0 ft flightline	3,600	313	509
75 ft downwind	1,200	344	378
150 ft downwind	640	542	209
225 ft downwind	280	584	167
300 ft downwind	160	730	127

1. Helicopter flight perpendicular to estimated 1 mph wind, at an altitude of 300 ft., using 7.5 flood jet nozzles and a boom pressure of 20 psi
2. 2.4 fluid oz. 91% Malathion and 9.6 fluid oz. Staley's Protein Insecticide Bait No. 7
3. Linearly arranged perpendicular to helicopter flightline

mean droplet diameter directly under the aircraft flightline to 127 μ mean droplet diameter 300 ft downwind. Conversely, the number of droplet per unit area increased with distance from a low value of 313 droplets per ft^2 on the flightline to 730 droplets per ft^2 downwind.

5.2.2 Fixed-Wing Swath Characterization

The DC-4 swath characterization produced results similar to those for the helicopter trial despite being completed on a different day and at a different location (Table 3). The two spray characterizations differed in magnitude in that the fixed-wing swath had significant deposits as far as 650 ft downwind of the flightline and maximum mass fallout and droplet deposition (no./unit area) occurred 200 ft and 300 ft downwind respectively. Mean droplet diameter decreased with distance.

5.2.3 Comparison of Aircraft Swaths

The systematic sampling of aircraft spray swaths clearly documented the importance of wind speed. Both the helicopter and fixed-wing trials were conducted under minimum wind conditions (estimated 1 mph or less). No droplets were detected upwind of the aircraft flightpaths under these mild wind conditions. These results demonstrate the dominating influence of wind with regard to spray drift and deposition.

6. ENVIRONMENTAL MONITORING OF AERIAL SPRAYS: MASS FALLOUT

6.1 Materials and Methods: Mass Fallout Deposition

Mass fallout deposition from the aerial sprays was monitored from two locations within each of the cells. Sampling sites were as close to the center of each cell as possible and were separated by at least 400 meters. All sites

Table 3. Characterization of fixed-wing aircraft swath[1] using baited malathion[2]

Sampling location[3]	Mass fallout ($\mu g/ft^2$)	Droplet count ($\#/ft^2$)	Mean droplet diameter (μ)
100 ft upwind	5	0	0
50 ft downwind	830	83	422
200 ft downwind	1450	678	251
350 ft downwind	542	886	198
500 ft downwind	292	615	189
650 ft downwind	208	511	145

1. DC-4 Flight perpendicular to 1 mph wind, at an altitude of 300 ft, using 4 flood nozzles at 20 psi boom pressure, 20 gallons per minute
2. 2.4 fluid oz. 91% Malathion and 9.6 fluid oz. Staley Protein Insecticide Bait No. 7
3. Linearly arranged perpendicular to aircraft flightline

were inspected for tall physical obstructions prior to the sprays and written approval for property access obtained from each property owner. Alternate site locations were obtained for each cell. Each mass fallout sampling site utilized a large polyethylene-covered cardboard base (18 x 36 in.) with two mass fallout sheets (10 x 14.5 in.) of a polyethylene-backed absorbent paper and one 3.25 x 4.25 in. droplet size card (Kromekote Cover 65 lb glossy paper). The droplet size card was stapled into a cardboard holder designed to prevent accidental smudging after collection and fastened to the baseboard with push-pins. Mass fallout sheets were also fastened to the baseboard with push-pins. In cases where moisture or low vegetation was present, the baseboards were secured in a horizontal plane to cement blocks approximately 15 inches off the ground.

The mass fallout baseboards with associated samples were set out a few hours prior to each spray. All samples were normally collected about one half hour after aircraft had sprayed the area. The mass fallout sheets were folded, polyethylene side out, wrapped in aluminum foil, immediately placed on dry ice, and kept frozen during shipment and prior to analysis. Droplet size cards, still mounted in their protective folders, were placed in manila envelopes and stored for later analysis. All samples were checked in at the conclusion of the spray operation, then flown to the Chemistry Laboratory in Sacramento the following morning for analysis. The droplet size cards were delivered to the Agricultural Engineering Department at the University of California at Davis, California, for droplet counting and sizing.

The polyethylene-backed absorbent paper samples were cut into 1 inch pieces and placed in a pint jar. The lid of the jar was covered with aluminum foil. Two hundred ml of ethyl acetate was added to the jar and the paper squares

were extracted for 20 minutes by shaking at 5 minute intervals. An aliquot of the resulting extract was injected directly into a gas chromatograph utilizing a 10% or 20% OV 101 on Chromosorb AWDS column 6 feet in length. The GC utilized a flame photometric detector run in the phosphorous mode.

6.2 Materials and Methods: Determination of Within and Between Cell Variation

Ten independent mass fallout monitoring locations were set up within a single cell to provide the basis for comparing variation within a given cell. The mean of the two monitoring sites normally utilized for mass fallout deposition was compared to the mean of the eight additional sites to determine whether significant differences occurred. Additionally, the mean mass fallout deposition derived from the two sites within each of the geographical cells was compared to determine whether significant differences occurred between cells in the study area.

6.3 Materials and Methods: Mass Deposition Degradation

A specific location was selected for a mass fallout degradation study using 17 x 34 in. Teflon sheets. A total of 32 sheets were set out prior to a spray. Replicate samples were then collected from randomized locations each day for five consecutive days to determine malathion degradation. The Teflon film was cut into pieces and placed in a 500 ml amber bottle which had been fitted with a Teflon lined lid. About 100 ml of 75:25 hexane/acetone (V/V) mixture was added to the jar. The sealed jar was placed in an ultrasonic bath for 1 hour. The solvent was then decanted and the bottle rinsed with three 15 ml aliquots of the solvent mixture. The decanted solvent and washings were combined and evaporated to near dryness on a roto-evaporator. The resulting volume was

made up to a final volume of 10 ml with ethyl acetate. One aliquot of the 10 ml sample was analyzed by GC utilizing a 6 ft long 3% SP 2100 on chromosorb AWDS column and a flame photometric detector (phosphorous mode).

6.4 Materials and Methods: Relationship of Mass Fallout Deposition and Malathion Water Concentration

A large man-made shallow pond and a large decorative fountain were selected within the spray area. Both sites lacked physical obstructions to interfere with mass fallout and provided security for sampling materials. A mass fallout sheet was located on land immediately adjacent to each water body to quantify deposition. A Teflon container with a surface area of 2 ft^2 was filled with 4 liters of water from the respective water bodies before each spray and allowed to float on the surface of the water body for temperature equilibration. After the selected sprays, the water within the container and the mass fallout sheet were collected, stored according to the type of sample and shipped to the Chemistry Laboraroty for analysis. Details of the procedures used for analysis of water samples, is presented in the appropriate section of this report.

6.5 Results: Mass Fallout of Baited Malathion

The initial aerial spray produced an average deposition ($\bar{x}$) of 1,366 $\mu g/ft^2$ of malathion for the cells sprayed. A total of 89 samples (n) were taken with a range of 0 to a high deposition rate of 6,400 $\mu g/ft^2$. The standard deviation of the sample population (sd) was 1,402 $\mu g/ft^2$ and the standard error of the mean (se) was 149 $\mu g/ft^2$. The data for sprays 2 through 6 are listed below using the same statistics:

Spray 2	n= 110	$\bar{x}$= 1,360 µg/ft^2	sd= 1,554 µg/ft^2	se= 126 µg/ft^2
Spray 3	n= 110	$\bar{x}$= 1,246 µg/ft^2	sd= 854 µg/ft^2	se= 82 µg/ft^2
Spray 4	n= 126	$\bar{x}$= 1,527 µg/ft^2	sd= 1,292 µg/ft^2	se= 115 µg/ft^2
Spray 5	n= 123	$\bar{x}$= 1,370 µg/ft^2	sd= 994 µg/ft^2	se= 90 µg/ft^2
Spray 6	n= 128	$\bar{x}$= 1,435 µg/ft^2	sd= 912 µg/ft^2	se= 81 µg/ft^2

These statistics summarize all mass fallout samples and therefore differ slightly from those displayed on Figures 3, 4, 5, and 6 which are restricted to the two monitoring sites in each cell. Samples such as the 10 mass fallout samples described in Section 6.2 were included here but not on the figures because of the need to use mean values of a standardized sample number for cell representations.

A visual comparison of mass fallout in the geographical cells of the study area (Figure 2) provides a summary of each spray week (Figures 3, 4, 5). It should be recognized that the values depicted for the cells are the mean value of the two assigned replicate mass fallout samples and do not represent extreme values monitored by individual samples. In the event only one value was available for a cell, the cell borders were plotted without the mean symbol. Most values plotted from any one spray fall below the theoretical application value (1,836 µg/ft^2), with a few cells having either very low or very high mass fallout values. The most probable explanation for these extreme values are overlapping flights for the high values and skips for the low values.

The average mass fallout deposition for each of the six sprays was remarkably consistent. Depositions of 1,366, 1,360, 1,246, 1,527, 1,370, and 1,434 µg/ft^2 were recorded for sprays 1 through 6 respectively, when all mass deposition values were included. These values were calculated for all monitored cells and include

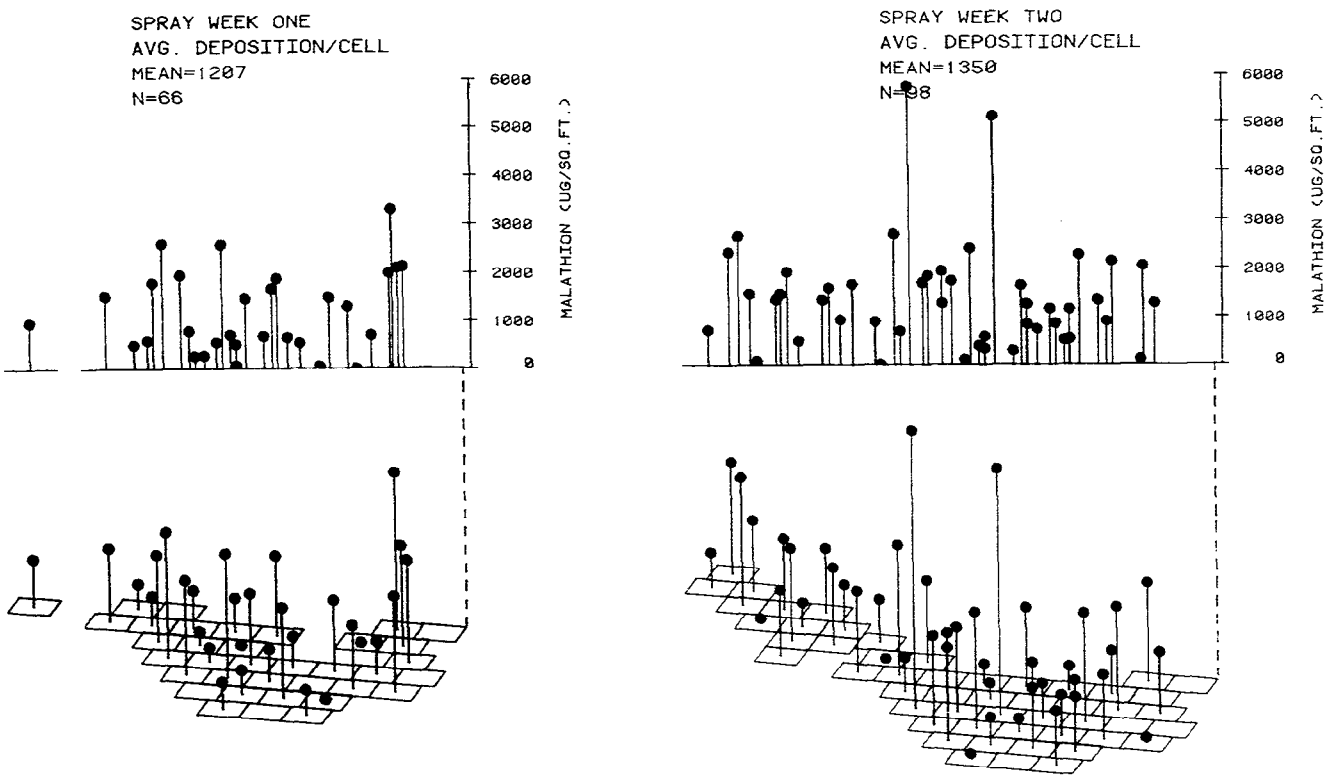

Figure 3. Average malathion deposition ($\mu g/ft^2$) per geographical cell for spray weeks 1 and 2 beginning July 14, 1981 and July 23, 1981, respectively. Each value represents the average of 2 individual deposition sites within each cell. Flagged sites, monitored sites outside the spray area and cells with only a single value are not plotted but are included in the calculation of the mean.

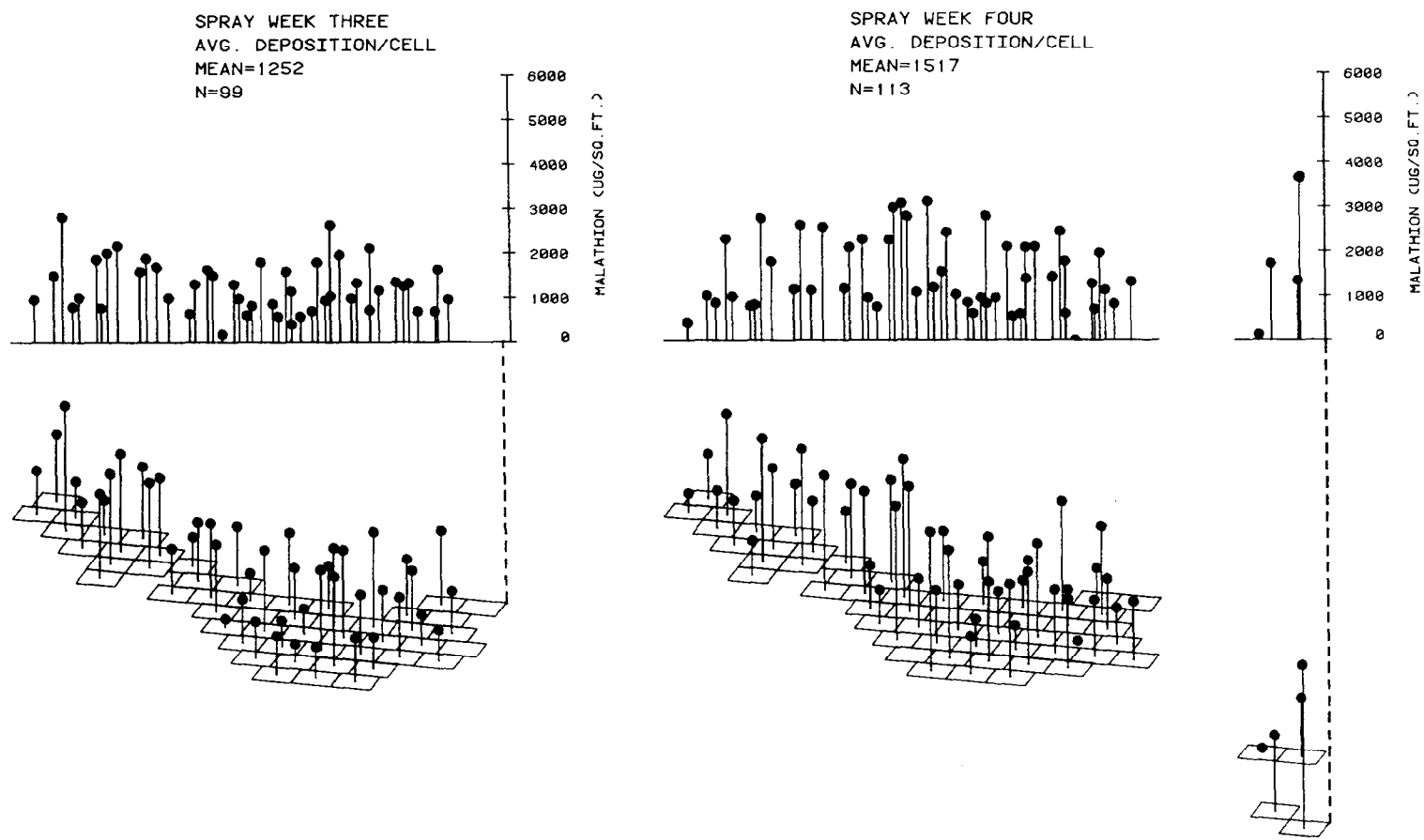

Figure 4. Average malathion deposition ($\mu g/ft^2$) per geographical cell for spray weeks 3 and 4 beginning August 3, 1981 and August 10, 1981, respectively. Each value represents the average of 2 individual deposition sites within each cell. Flagged sites, monitored sites outside the spray area and cells with only a single value are not plotted but are included in the calculation of the mean.

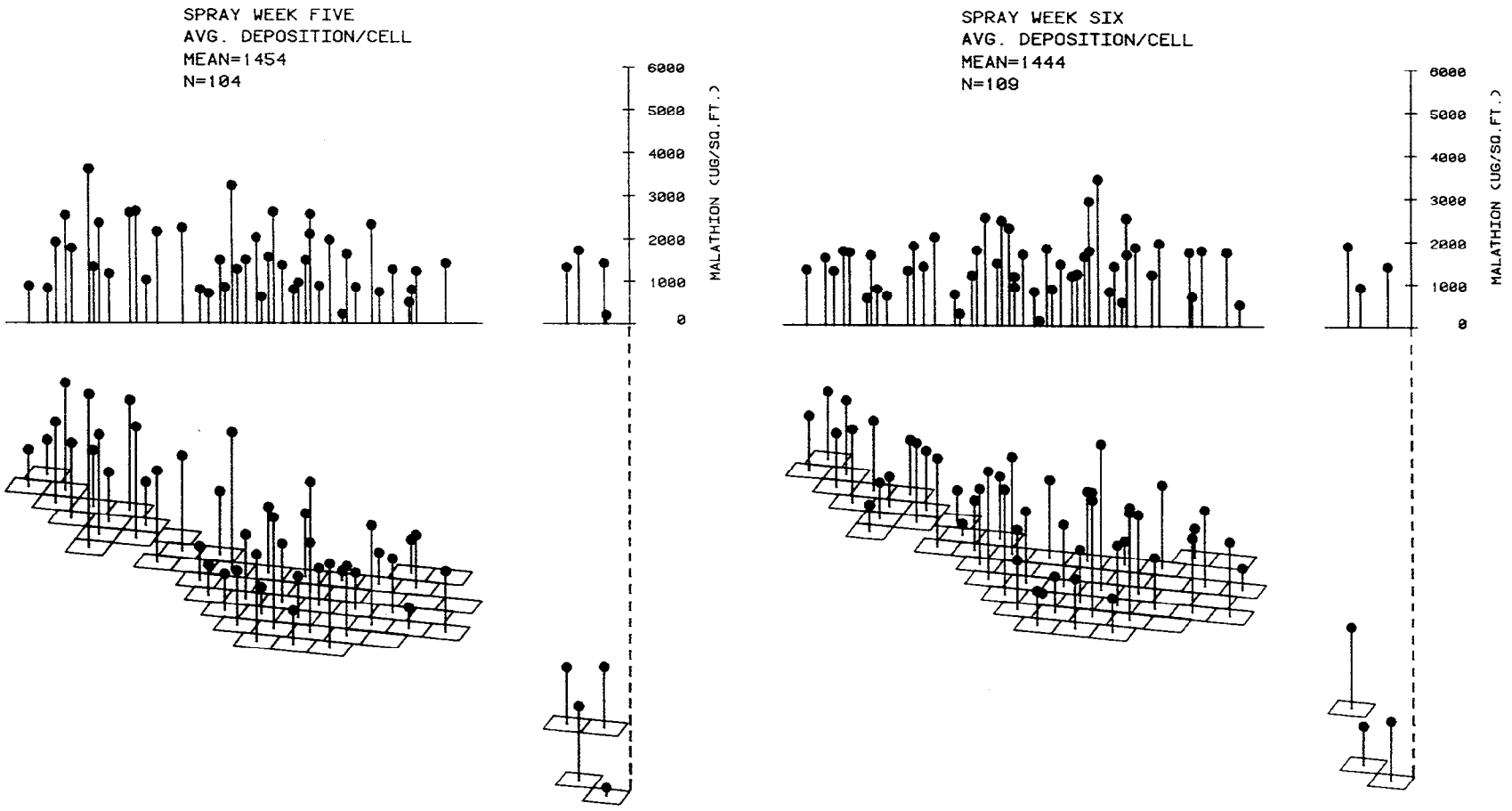

Figure 5. Average malathion deposition ($\mu g/ft^2$) per geographical cell for spray weeks 5 and 6 beginning August 17, 1981 and August 25, 1981, respectively. Each value represents the average of 2 individual deposition sites within each cell. Flagged sites, monitored sites outside the spray area and cells with only a single value are not plotted but are included in the calculation of the mean.

samples in addition to the two routinely collected from each cell. The consistency of the mass fallout was maintained despite the increased geographical area, contracting of two aerial spray firms to apply the baited malathion and the logistical problems involved in expanding the aircraft guidance systems.

The variability among the cells for any single spray is moderate when all six sprays are considered. As can be seen in Figure 6, the variability characterizing single sprays is no longer apparent when the average mass fallout for six sprays is calculated. The mean mass fallout for the six spray series was 1,385 $\mu g/ft^2$.

The mass fallout deposition in areas flagged for exclusion from spraying was significant despite efforts to isolate them. Although a single flagged area received significant mass fallout during spray 1 (Figure 7), this was the first and smallest area sprayed. Subsequent sprays were not as successful in avoiding flagged areas (Figure 7, 8, 9). Numerous instances of significant mass deposition were documented. The intrusions into these areas did not produce high levels of malathion vapor. The vapor phase monitoring in flagged areas is discussed in the air monitoring section of this report.

A careful evaluation of the aerial spray requires the scrutiny of the individual mass fallout deposition samples and their correlation with the aircraft swath characterizations. Given the variability in the mass fallout deposition from a single swath (Table 2), the variation viewed in plots of individual mass fallout samples was not unexpected (Figure 10). Once again, the extreme values must be attributed to skips and multiple aerial sprays, and errors involved with the guidance system. Mass fallout deposition samples in excess of the normal two per cell were situated at water monitoring, residential air monitoring and

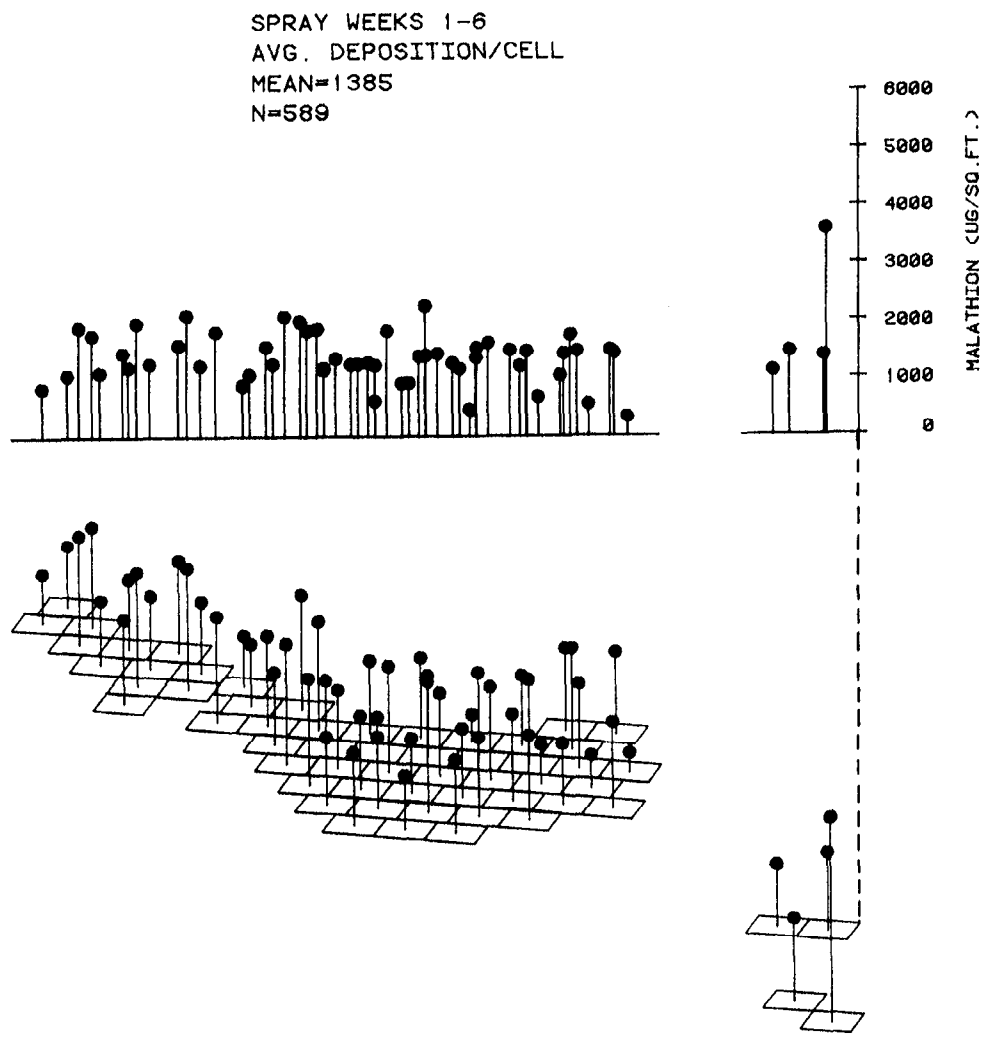

Figure 6. Average malathion deposition ($\mu g/ft^2$) per geographical cell for spray weeks 1 through 6 inclusive beginning July 14, 1981 and ending August 31, 1981. Each value represents the 6 spray week mean value calculated from the individual mass deposition values for the total period. Flagged sites and monitored sites outside the spray area are not included.

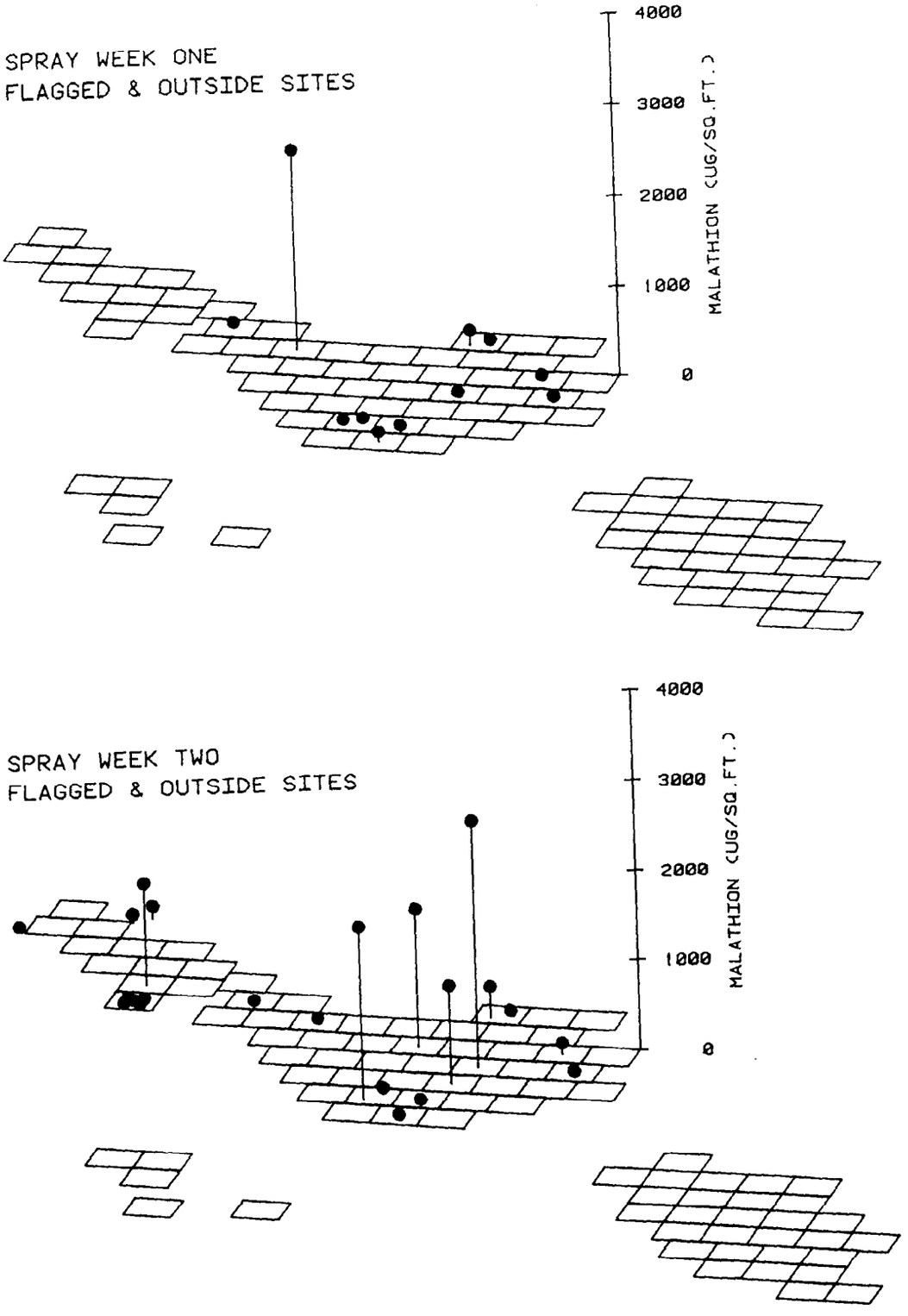

Figure 7. Mass fallout deposition of malathion ($\mu g/ft^2$) from flagged locations and monitoring sites outside of the spray area during spray weeks 1 and 2 beginnig July 14, 1981 and July 23, 1981 respectively.

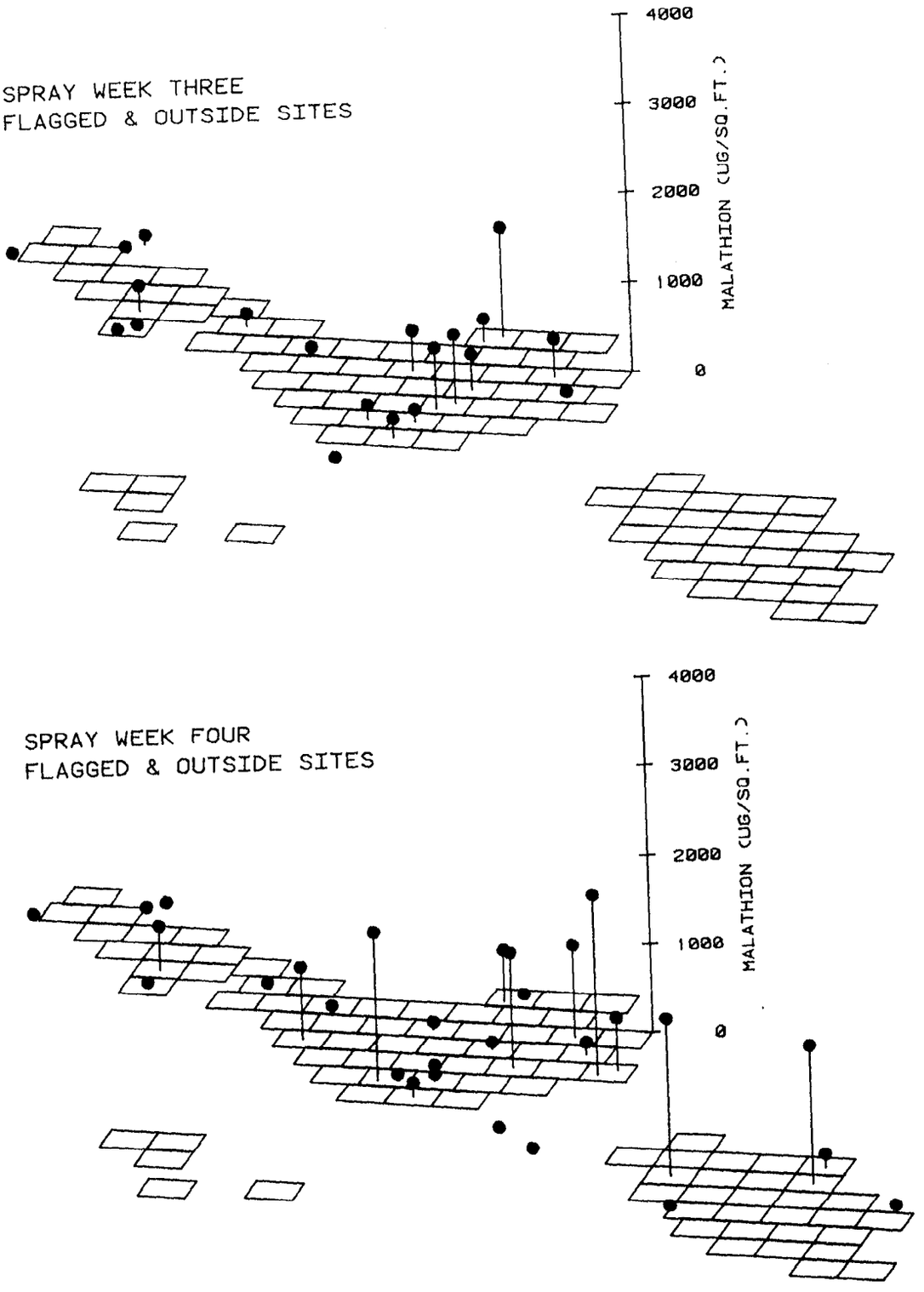

Figure 8. Mass fallout deposition of malathion ($\mu g/ft^2$) from flagged locations and monitoring sites outside of the spray area during spray weeks 3 and 4 beginning August 3, 1981 and August 10, 1981 respectively.

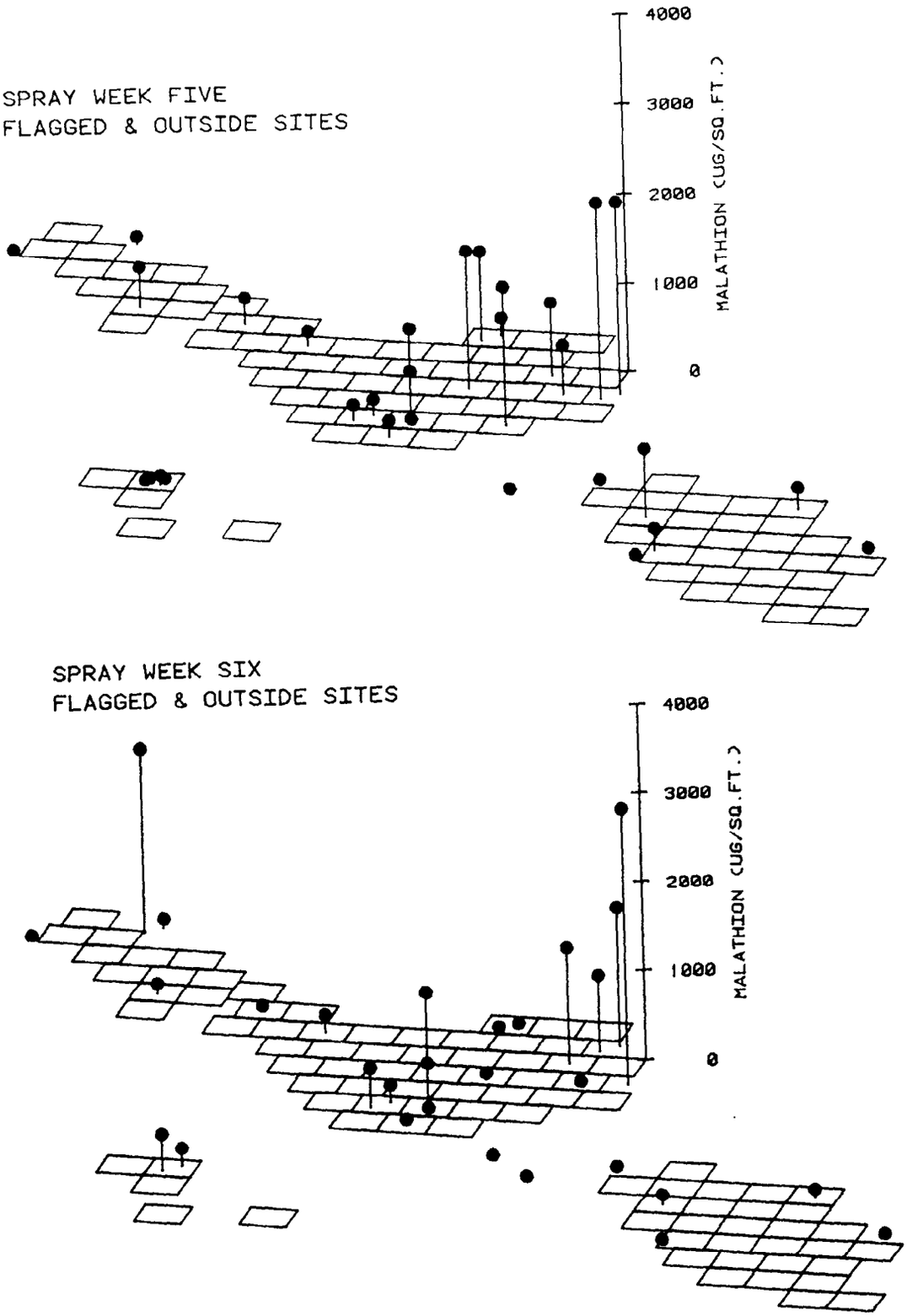

Figure 9. Mass fallout deposition of malathion ($\mu g/ft^2$) from flagged locations and monitoring sites outside of the spray area during spray weeks 5 and 6 beginning August 17, 1981 and August 24, 1981 respectively.

nursing home/convalescent hospital air monitoring sites. These samples were utilized to characterize mass deposition at the respective sites but could not be utilized in the cell averages.

6.5.1 Results: Droplet Size Characterization

A qualitative check on the consistency of the droplet size and mass deposition data bases was undertaken. Droplet sizes were classified according to their diameters after correction for impact in 12 size ranges. The droplet count per unit area was calculated for each size range and an estimate of the corresponding mass deposit was inferred using the known malathion-bait mass density together with the malathion-to-bait (V:V) ratio. The resulting calculated total mass deposit was found to be qualitatively consistent with the measured mass deposit. It must be emphasized, however, that the finite droplet size ranges that were selected strongly influenced the calculated mass deposit.

The detailed analyses of the droplet sizes sampled from the geographical cells is summarized in Tables 4 - 17. The droplet size distribution is referenced both by size range (microns) and calculated volumetric mean diameter for that size range. Additionally, the number of particles, percent of total number, and cumulative percent of total number statistics are provided for the droplet size ranges. A calculated number of droplets per ft^2 and theoretical calculations of three mass statistics are also presented to provide some perspective and aid in evaluating the droplet data. It is important to point out that the total droplets category presented in the tables is a summary by size category and does not depict the number to mass relationship documented by the swath width trials (Tables 1 and 2). The monitoring data presented in Tables 4 - 17 does, however, indicate differences in summary statistics depending on the reference. The mean size referenced to particle number was between 2 to 3 times smaller than

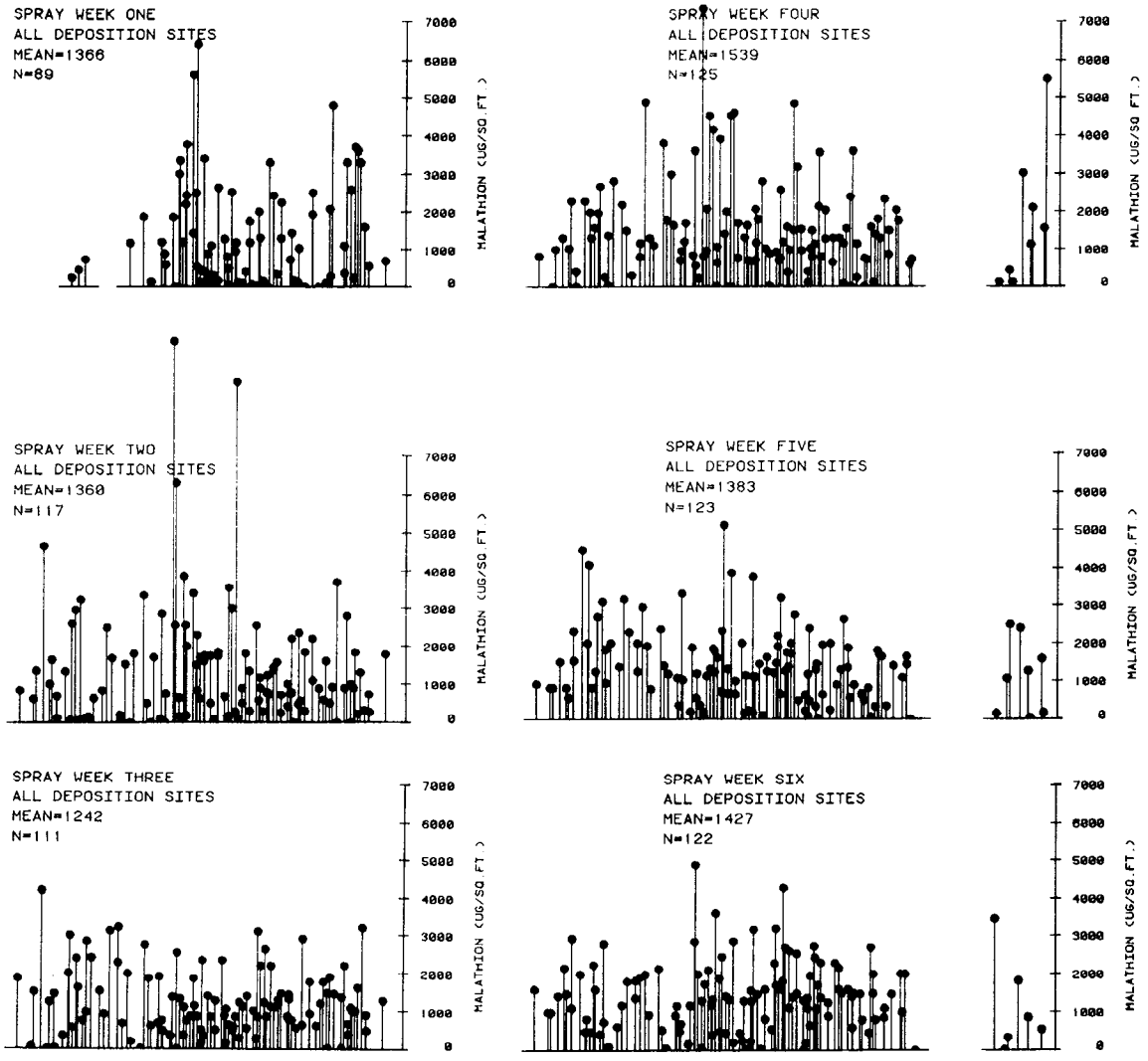

Figure 10. Individual values for mass fallout deposition of malathion ($\mu g/ft^2$) at individual sampling sites for spray week 1 beginning July 14, 1981, spray week 2 beginning July 23, 1981, spray week 3 beginning August 3, 1981, spray week 4 beginning August 10, 1981, spray week 5 beginning August 17, 1981 and spray week 6 beginning August 24, 1981. Up to a maximum of 5 individual deposition sites for each geographical cell are plotted for each spray week. Flagged locations or sites outside the spray area are not included.

the mean size referenced to mass. One need only go down the cumulative percent number column to 50% and find the appropriate volumetric diameter and compare this to the corresponding value from the same exercise in the cumulative percent mass column. In summary, the larger droplet sizes are responsible for the greatest proportion of mass fallout deposition and the smaller size ranges contribute very little to the total mass deposited.

Distribution functions describing volumetric mean diameter as a function of cumulative percent number of droplets in each size category were calculated for each spray using linear regression (Figure 11). The functions were presented to facilitate obtaining a quick characterization of the droplet size distribution from a sample of individual sprays and the average distribution for six sprays. One need only to determine the desired proportion on the x axis and move vertically to the specific function, then horizontally to the y axis to obtain the maximum droplet size characterizing that proportion of the total droplets for an individual spray or the six spray series. Statistics for all sprays and the six spray average for flagged and non-flagged areas are presented in the tables but are somewhat more cumbersome to use.

The droplet size distribution did not differ between flagged areas and the normal spray areas (Tables 4 - 17). Student's t tests calculated for the comparisons of distributions proved to be non-significant ($P \leq 0.05$). However, if one scrutinizes the proportion of droplets in the larger size ranges isolated from the remaining categories, it appears that a lesser proportion of large particles fall within flagged areas. This evaluation may not be justified, however, because of the grossly unequal sample sizes. Ten times more samples were collected from the spray area compared to flagged areas. The apparent

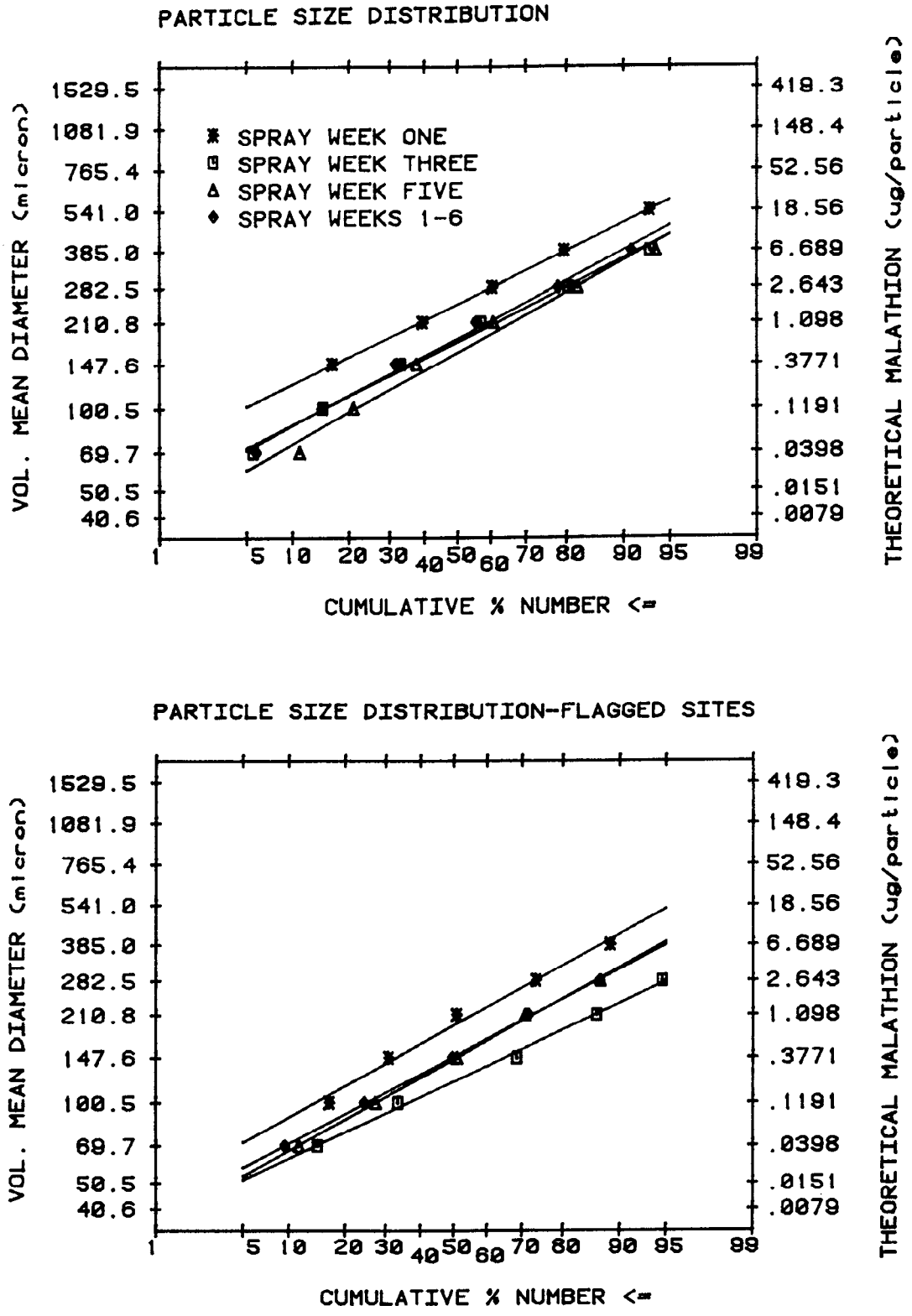

Figure 11. Linear functions relating the proportion of total number of sampled particles equal to or less than a volumetric mean diameter for spray week 1 beginning July 14, 1981, spray week 3 beginning August 3, 1981, spray week 5 beginning August 17 and for the average of spray 1-6 beginning July 14 and terminating August 30, 1981.

TABLE 4. Measured and calculated droplet size characteristics of aerially applied baited malathion during spray week 1 beginning July 14, 1981.

SIZE RANGE LIMIT (microns)	VOLUMETRIC MEAN DIAMETER[1] (microns)	TOTAL NUMBER DROPLETS	DROPLET DENSITY[2] (NO./FT^2)	PERCENT NUMBER	CUMULATIVE PERCENT NUMBER	CALCULATED MASS MALATHION[3]	CALCULATED PERCENT MASS	CUMULATIVE PERCENT MASS
35								
	40.62	0	0.00	0.00	0.00	0.000000	0.00	0.00
45								
	50.50	0	0.00	0.00	0.00	0.000000	0.00	0.00
55								
	69.74	30	4.29	0.82	0.82	0.000001	0.00[4]	0.00[4]
80								
	100.54	150	21.43	4.09	4.91	0.000018	0.04	0.04
115								
	147.62	432	61.71	11.78	16.68	0.000163	0.37	0.42
170								
	210.81	815	116.43	22.22	38.90	0.000895	2.05	2.47
240								
	282.48	782	111.71	21.32	60.22	0.002066	4.73	7.20
315								
	385.00	699	99.86	19.06	79.28	0.004676	10.71	17.90
436								
	540.97	505	72.14	13.77	93.05	0.009371	21.45	39.36
616								
	765.40	192	27.43	5.23	98.28	0.010091	23.10	62.46
872								
	1081.94	37	5.29	1.01	99.29	0.005493	12.58	75.03
1232								
	1529.50	26	3.71	0.71	100.00	0.010904	24.97	100.00
1742								

1- Calculation made by converting size range limits to volumes and obtaining the mean volumetric diameter.
2- Calculation based on the distribution of the total population, sized from 84 collection cards.
3- Mass in micrograms Malathion, calculated using the volumetric mean diameter and 1.23 gm/cm^3 density Malathion, applied to the mix ratio of 9.6 oz bait with 2.4 oz of 91% Malathion.
4- Depicts a value smaller than 0.0000005 micrograms mass or 0.005 percent.

TABLE 5. Measured and calculated droplet size characteristics of aerially applied baited malathion during spray week 2 beginning July 23, 1981.

SIZE RANGE LIMIT (microns)	VOLUMETRIC MEAN DIAMETER[1] (microns)	TOTAL NUMBER DROPLETS	DROPLET DENSITY[2] (NO./FT^2)	PERCENT NUMBER	CUMULATIVE PERCENT NUMBER	CALCULATED MASS MALATHION[3]	CALCULATED PERCENT MASS	CUMULATIVE PERCENT MASS
35								
	40.62	3	0.31	0.07	0.07	0.000000[4]	0.00[4]	0.00[4]
45								
	50.50	4	0.41	0.09	0.16	0.000000[4]	0.00[4]	0.00[4]
55								
	69.74	208	21.33	4.84	5.01	0.000008	0.03	0.03
80								
	100.54	347	35.59	8.08	13.09	0.000041	0.13	0.16
115								
	147.62	657	67.38	15.30	28.39	0.000248	0.78	0.93
170								
	210.81	848	86.97	19.75	48.14	0.000931	2.93	3.86
240								
	282.48	1082	110.97	25.20	73.33	0.002859	8.98	12.84
315								
	385.00	612	62.77	14.25	87.59	0.004094	12.86	25.70
436								
	540.97	366	37.54	8.52	96.11	0.006792	21.34	47.04
616								
	765.40	111	11.38	2.59	98.70	0.005834	18.33	65.37
872								
	1081.94	46	4.72	1.07	99.77	0.006829	21.45	86.82
1232								
	1529.50	10	1.03	0.23	100.00	0.004194	13.18	100.00
1742								

1- Calculation made by converting size range limits to volumes and obtaining the mean volumetric diameter.
2- Calculation based on the distribution of the total population, sized from 117 collection cards.
3- Mass in micrograms Malathion, calculated using the volumetric mean diameter and 1.23 gm/cm^3 density Malathion, applied to the mix ratio of 9.6 oz bait with 2.4 oz of 91% Malathion.
4- Depicts a value smaller than 0.0000005 micrograms mass or 0.005 percent.

TABLE 6. Measured and calculated droplet size characteristics of aerially applied baited malathion during spray week 3 beginning August 3, 1981.

SIZE RANGE LIMIT (microns)	VOLUMETRIC MEAN DIAMETER[1] (microns)	TOTAL NUMBER DROPLETS	DROPLET DENSITY[2] (NO./FT^2)	PERCENT NUMBER	CUMULATIVE PERCENT NUMBER	CALCULATED MASS MALATHION[3]	CALCULATED PERCENT MASS	CUMULATIVE PERCENT MASS
35								
	40.62	0	0.00	0.00	0.00	0.000000	0.00	0.00
45								
	50.50	18	2.04	0.37	0.37	0.000000[4]	0.00[4]	0.00[4]
55								
	69.74	254	28.75	5.18	5.54	0.000010	0.05	0.05
80								
	100.54	450	50.94	9.17	14.72	0.000054	0.25	0.29
115								
	147.62	899	101.77	18.32	33.04	0.000339	1.56	1.85
170								
	210.81	1188	134.49	24.22	57.26	0.001305	6.00	7.85
240								
	282.48	1138	128.83	23.20	80.45	0.003007	13.83	21.69
315								
	385.00	624	70.64	12.72	93.17	0.004174	19.20	40.89
436								
	540.97	230	26.04	4.69	97.86	0.004268	19.63	60.52
616								
	765.40	90	10.19	1.83	99.69	0.004730	21.76	82.28
872								
	1081.94	9	1.02	0.18	99.88	0.001336	6.15	88.42
1232								
	1529.50	6	0.68	0.12	100.00	0.002516	11.58	100.00
1742								

1- Calculation made by converting size range limits to volumes and obtaining the mean volumetric diameter.
2- Calculation based on the distribution of the total population, sized from 106 collection cards.
3- Mass in micrograms Malathion, calculated using the volumetric mean diameter and 1.23 gm/cm^3 density Malathion, applied to the mix ratio of 9.6 oz bait with 2.4 oz of 91% Malathion.
4- Depicts a value smaller than 0.0000005 micrograms mass or 0.005 percent.

TABLE 7. Measured and calculated droplet size characteristics of aerially applied baited malathion during spray week 4 beginning August 10, 1981.

SIZE RANGE LIMIT (microns)	VOLUMETRIC MEAN DIAMETER[1] (microns)	TOTAL NUMBER DROPLETS	DROPLET DENSITY[2] (NO./FT^2)	PERCENT NUMBER	CUMULATIVE PERCENT NUMBER	CALCULATED MASS MALATHION[3]	CALCULATED PERCENT MASS	CUMULATIVE PERCENT MASS
35								
	40.62	0	0.00	0.00	0.00	0.000000	0.00	0.00
45								
	50.50	3	0.32	0.04	0.04	0.000000[4]	0.00[4]	0.00[4]
55								
	69.74	173	18.21	2.44	2.49	0.000007	0.02	0.02
80								
	100.54	580	61.05	8.19	10.68	0.000069	0.20	0.22
115								
	147.62	1156	121.68	16.33	27.01	0.000436	1.28	1.51
170								
	210.81	1956	205.89	27.63	54.64	0.002148	6.33	7.84
240								
	282.48	1730	182.11	24.44	79.08	0.004571	13.47	21.30
315								
	385.00	892	93.89	12.60	91.68	0.005967	17.58	38.88
436								
	540.97	414	43.58	5.85	97.53	0.007682	22.63	61.52
616								
	765.40	146	15.37	2.06	99.59	0.007673	22.61	84.12
872								
	1081.94	25	2.63	0.35	99.94	0.003711	10.93	95.06
1232								
	1529.50	4	0.42	0.06	100.00	0.001678	4.94	100.00
1742								

1- Calculation made by converting size range limits to volumes and obtaining the mean volumetric diameter.
2- Calculation based on the distribution of the total population, sized from 114 collection cards.
3- Mass in micrograms Malathion, calculated using the volumetric mean diameter and 1.23 gm/cm^3 density Malathion, applied to the mix ratio of 9.6 oz bait with 2.4 oz of 91% Malathion.
4- Depicts a value smaller than 0.0000005 micrograms mass or 0.005 percent.

TABLE 8. Measured and calculated droplet size characteristics of aerially applied baited malathion during spray week 5 beginning August 17, 1981.

SIZE RANGE LIMIT (microns)	VOLUMETRIC MEAN DIAMETER[1] (microns)	TOTAL NUMBER DROPLETS	DROPLET DENSITY[2] (NO./FT^2)	PERCENT NUMBER	CUMULATIVE PERCENT NUMBER	CALCULATED MASS MALATHION[3]	CALCULATED PERCENT MASS	CUMULATIVE PERCENT MASS
35								
	40.62	21	2.07	0.29	0.29	0.000000[4]	0.00[4]	0.00[4]
45								
	50.50	97	9.54	1.35	1.64	0.000001	0.01	0.01
55								
	69.74	671	66.00	9.34	10.98	0.000027	0.10	0.11
80								
	100.54	723	71.11	10.06	21.04	0.000086	0.34	0.45
115								
	147.62	1187	116.75	16.52	37.56	0.000448	1.76	2.21
170								
	210.81	1679	165.15	23.37	60.93	0.001844	7.24	9.45
240								
	282.48	1537	151.18	21.39	82.32	0.004061	15.95	25.40
315								
	385.00	820	80.66	11.41	93.74	0.005485	21.55	46.95
436								
	540.97	343	33.74	4.77	98.51	0.006365	25.00	71.95
616								
	765.40	94	9.25	1.31	99.82	0.004940	19.41	91.36
872								
	1081.94	12	1.18	0.17	99.99	0.001781	7.00	98.35
1232								
	1529.50	1	0.10	0.01	100.00	0.000419	1.65	100.00
1742								

1- Calculation made by converting size range limits to volumes and obtaining the mean volumetric diameter.
2- Calculation based on the distribution of the total population, sized from 122 collection cards.
3- Mass in micrograms Malathion, calculated using the volumetric mean diameter and 1.23 gm/cm^3 density Malathion, applied to the mix ratio of 9.6 oz bait with 2.4 oz of 91% Malathion.
4- Depicts a value smaller than 0.0000005 micrograms mass or 0.005 percent.

TABLE 9. Measured and calculated droplet size characteristics of aerially applied baited malathion during spray week 6 beginning August 24, 1981.

SIZE RANGE LIMIT (microns)	VOLUMETRIC MEAN DIAMETER[1] (microns)	TOTAL NUMBER DROPLETS	DROPLET DENSITY[2] (NO./FT^2)	PERCENT NUMBER	CUMULATIVE PERCENT NUMBER	CALCULATED MASS MALATHION[3]	CALCULATED PERCENT MASS	CUMULATIVE PERCENT MASS
35								
	40.62	8	0.86	0.13	0.13	0.000000[4]	0.00[4]	0.00[4]
45								
	50.50	31	3.35	0.49	0.62	0.000000[4]	0.00[4]	0.00[4]
55								
	69.74	432	46.70	6.84	7.45	0.000017	0.08	0.08
80								
	100.54	683	73.84	10.81	18.27	0.000081	0.38	0.46
115								
	147.62	1307	141.30	20.69	38.95	0.000493	2.30	2.76
170								
	210.81	1585	171.35	25.09	64.04	0.001740	8.12	10.88
240								
	282.48	1278	138.16	20.23	84.27	0.003376	15.74	26.62
315								
	385.00	656	70.92	10.38	94.65	0.004388	20.46	47.08
436								
	540.97	239	25.84	3.78	98.43	0.004435	20.68	67.77
616								
	765.40	84	9.08	1.33	99.76	0.004415	20.59	88.35
872								
	1081.94	14	1.51	0.22	99.98	0.002078	9.69	98.04
1232								
	1529.50	1	0.11	0.02	100.00	0.000419	1.96	100.00
1742								

1- Calculation made by converting size range limits to volumes and obtaining the mean volumetric diameter.
2- Calculation based on the distribution of the total population, sized from 111 collection cards.
3- Mass in micrograms Malathion, calculated using the volumetric mean diameter and 1.23 gm/cm^3 density Malathion, applied to the mix ratio of 9.6 oz bait with 2.4 oz of 91% Malathion.
4- Depicts a value smaller than 0.0000005 micrograms mass or 0.005 percent.

TABLE 10. Measured and calculated droplet size characteristics of aerially applied baited malathion during spray weeks 1-6 beginning July 14, 1981.

SIZE RANGE LIMIT (microns)	VOLUMETRIC MEAN DIAMETER[1] (microns)	TOTAL NUMBER DROPLETS	DROPLET DENSITY[2] (NO./FT^2)	PERCENT NUMBER	CUMULATIVE PERCENT NUMBER	CALCULATED MASS MALATHION[3]	CALCULATED PERCENT MASS	CUMULATIVE PERCENT MASS
35								
	40.62	32	0.59	0.10	0.10	0.000000[4]	0.00[4]	0.00[4]
45								
	50.50	153	2.81	0.46	0.55	0.000002	0.00[4]	0.00[4]
55								
	69.74	1768	32.44	5.29	5.84	0.000070	0.04	0.04
80								
	100.54	2933	53.82	8.77	14.61	0.000349	0.20	0.24
115								
	147.62	5638	103.45	16.86	31.46	0.002126	1.19	1.43
170								
	210.81	8071	148.09	24.13	55.59	0.008863	4.98	6.41
240								
	282.48	7547	138.48	22.56	78.15	0.019939	11.20	17.60
315								
	385.00	4303	78.95	12.86	91.02	0.028784	16.16	33.77
436								
	540.97	2097	38.48	6.27	97.29	0.038913	21.85	55.62
616								
	765.40	717	13.16	2.14	99.43	0.037684	21.16	76.78
872								
	1081.94	143	2.62	0.43	99.86	0.021228	11.92	88.70
1232								
	1529.50	48	0.88	0.14	100.00	0.020131	11.30	100.00
1742								

1- Calculation made by converting size range limits to volumes and obtaining the mean volumetric diameter.
2- Calculation based on the distribution of the total population, sized from 654 collection cards.
3- Mass in micrograms Malathion, calculated using the volumetric mean diameter and 1.23 gm/cm^3 density Malathion, applied to the mix ratio of 9.6 oz bait with 2.4 oz of 91% Malathion.
4- Depicts a value smaller than 0.0000005 micrograms mass or 0.005 percent.

TABLE 11. Measured and calculated droplet size characteristics of aerially applied baited malathion from flagged sites during spray week 1 beginning July 14, 1981.

SIZE RANGE LIMIT (microns)	VOLUMETRIC MEAN DIAMETER[1] (microns)	TOTAL NUMBER DROPLETS	DROPLET DENSITY[2] (NO./FT^2)	PERCENT NUMBER	CUMULATIVE PERCENT NUMBER	CALCULATED MASS MALATHION[3]	CALCULATED PERCENT MASS	CUMULATIVE PERCENT MASS
35								
	40.62	0	0.00	0.00	0.00	0.000000	0.00	0.00
45								
	50.50	0	0.00	0.00	0.00	0.000000	0.00	0.00
55								
	69.74	0	0.00	0.00	0.00	0.000000	0.00	0.00
80								
	100.54	19	25.33	16.67	16.67	0.000002	0.50	0.50
115								
	147.62	16	21.33	14.04	30.70	0.000006	1.32	1.81
170								
	210.81	23	30.67	20.18	50.88	0.000025	5.52	7.34
240								
	282.48	26	34.67	22.81	73.68	0.000069	15.02	22.36
315								
	385.00	17	22.67	14.91	88.60	0.000114	24.87	47.24
436								
	540.97	13	17.33	11.40	100.00	0.000241	52.76	100.00
616								
	765.40	0	0.00	0.00	100.00	0.000000	0.00	100.00
872								
	1081.94	0	0.00	0.00	100.00	0.000000	0.00	100.00
1232								
	1529.50	0	0.00	0.00	100.00	0.000000	0.00	100.00
1742								

1- Calculation made by converting size range limits to volumes and obtaining the mean volumetric diameter.
2- Calculation based on the distribution of the total population, sized from 9 collection cards.
3- Mass in micrograms Malathion, calculated using the volumetric mean diameter and 1.23 gm/cm^3 density Malathion.

TABLE 12. Measured and calculated droplet size characteristics of aerially applied baited malathion from flagged sites during spray week 2 beginning July 23, 1981.

SIZE RANGE LIMIT (microns)	VOLUMETRIC MEAN DIAMETER[1] (microns)	TOTAL NUMBER DROPLETS	DROPLET DENSITY[2] (NO./FT^2)	PERCENT NUMBER	CUMULATIVE PERCENT NUMBER	CALCULATED MASS MALATHION[3]	CALCULATED PERCENT MASS	CUMULATIVE PERCENT MASS
35								
	40.62	0	0.00	0.00	0.00	0.000000	0.00	0.00
45								
	50.50	0	0.00	0.00	0.00	0.000000	0.00	0.00
55								
	69.74	22	20.31	9.09	9.09	0.000001	0.11	0.11
80								
	100.54	42	38.77	17.36	26.45	0.000005	0.66	0.77
115								
	147.62	53	48.92	21.90	48.35	0.000020	2.62	3.39
170								
	210.81	58	53.54	23.97	72.31	0.000064	8.36	11.75
240								
	282.48	41	37.85	16.94	89.26	0.000108	14.21	25.96
315								
	385.00	15	13.85	6.20	95.45	0.000100	13.17	39.13
436								
	540.97	9	8.31	3.72	99.17	0.000167	21.91	61.04
616								
	765.40	0	0.00	0.00	99.17	0.000000	0.00	61.04
872								
	1081.94	2	1.85	0.83	100.00	0.000297	38.96	100.00
1232								
	1529.50	0	0.00	0.00	100.00	0.000000	0.00	100.00
1742								

1- Calculation made by converting size range limits to volumes and obtaining the mean volumetric diameter.
2- Calculation based on the distribution of the total population, sized from 13 collection cards.
3- Mass in micrograms Malathion, calculated using the volumetric mean diameter and 1.23 gm/cm^3 density Malathion.

TABLE 13. Measured and calculated droplet size characteristics of aerially applied baited malathion from flagged sites during spray week 3 beginning August 3, 1981.

SIZE RANGE LIMIT (microns)	VOLUMETRIC MEAN DIAMETER[1] (microns)	TOTAL NUMBER DROPLETS	DROPLET DENSITY[2] (NO./FT^2)	PERCENT NUMBER	CUMULATIVE PERCENT NUMBER	CALCULATED MASS MALATHION[3]	CALCULATED PERCENT MASS	CUMULATIVE PERCENT MASS
35								
	40.62	0	0.00	0.00	0.00	0.000000	0.00	0.00
45								
	50.50	0	0.00	0.00	0.00	0.000000	0.00	0.00
55								
	69.74	30	36.00	14.49	14.49	0.000001	0.55	0.55
80								
	100.54	39	46.80	18.84	33.33	0.000005	2.15	2.70
115								
	147.62	73	87.60	35.27	68.60	0.000028	12.73	15.43
170								
	210.81	37	44.40	17.87	86.47	0.000041	18.79	34.22
240								
	282.48	17	20.40	8.21	94.69	0.000045	20.77	54.99
315								
	385.00	9	10.80	4.35	99.03	0.000060	27.84	82.84
436								
	540.97	2	2.40	0.97	100.00	0.000037	17.16	100.00
616								
	765.40	0	0.00	0.00	100.00	0.000000	0.00	100.00
872								
	1081.94	0	0.00	0.00	100.00	0.000000	0.00	100.00
1232								
	1529.50	0	0.00	0.00	100.00	0.000000	0.00	100.00
1742								

1- Calculation made by converting size range limits to volumes and obtaining the mean volumetric diameter.
2- Calculation based on the distribution of the total population, sized from 10 collection cards.
3- Mass in micrograms Malathion, calculated using the volumetric mean diameter and 1.23 gm/cm^3 density Malathion.

TABLE 14. Measured and calculated droplet size characteristics of aerially applied baited malathion from flagged sites during spray week 4 beginning August 10, 1981.

SIZE RANGE LIMIT (microns)	VOLUMETRIC MEAN DIAMETER[1] (microns)	TOTAL NUMBER DROPLETS	DROPLET DENSITY[2] (NO./FT^2)	PERCENT NUMBER	CUMULATIVE PERCENT NUMBER	CALCULATED MASS MALATHION[3]	CALCULATED PERCENT MASS	CUMULATIVE PERCENT MASS
35								
	40.62	0	0.00	0.00	0.00	0.000000	0.00	0.00
45								
	50.50	0	0.00	0.00	0.00	0.000000	0.00	0.00
55								
	69.74	6	6.55	2.05	2.05	0.000000[4]	0.02	0.02
80								
	100.54	38	41.45	13.01	15.07	0.000005	0.47	0.49
115								
	147.62	82	89.45	28.08	43.15	0.000031	3.21	3.70
170								
	210.81	68	74.18	23.29	66.44	0.000075	7.75	11.45
240								
	282.48	53	57.82	18.15	84.59	0.000140	14.52	25.97
315								
	385.00	44	48.00	15.07	99.66	0.000294	30.53	56.50
436								
	540.97	0	0.00	0.00	99.66	0.000000	0.00	56.50
616								
	765.40	0	0.00	0.00	99.66	0.000000	0.00	56.50
872								
	1081.94	0	0.00	0.00	99.66	0.000000	0.00	56.50
1232								
	1529.50	1	1.09	0.34	100.00	0.000419	43.50	100.00
1742								

1- Calculation made by converting size range limits to volumes and obtaining the mean volumetric diameter.
2- Calculation based on the distribution of the total population, sized from 11 collection cards.
3- Mass in micrograms Malathion, calculated using the volumetric mean diameter and 1.23 gm/cm^3 density Malathion.
4- Depicts a value smaller than 0.0000005 micrograms mass or 0.005 percent.

TABLE 15. Measured and calculated droplet size characteristics of aerially applied baited malathion from flagged sites during spray week 5 beginning August 17, 1981.

SIZE RANGE LIMIT (microns)	VOLUMETRIC MEAN DIAMETER[1] (microns)	TOTAL NUMBER DROPLETS	DROPLET DENSITY[2] (NO./FT^2)	PERCENT NUMBER	CUMULATIVE PERCENT NUMBER	CALCULATED MASS MALATHION[3]	CALCULATED PERCENT MASS	CUMULATIVE PERCENT MASS
35								
	40.62	0	0.00	0.00	0.00	0.000000	0.00	0.00
45								
	50.50	0	0.00	0.00	0.00	0.000000	0.00	0.00
55								
	69.74	39	46.80	11.44	11.44	0.000002	0.21	0.21
80								
	100.54	54	64.80	15.84	27.27	0.000006	0.85	1.06
115								
	147.62	81	97.20	23.75	51.03	0.000031	4.06	5.12
170								
	210.81	68	81.60	19.94	70.97	0.000075	9.92	15.03
240								
	282.48	55	66.00	16.13	87.10	0.000145	19.30	34.33
315								
	385.00	30	36.00	8.80	95.89	0.000201	26.65	60.98
436								
	540.97	13	15.60	3.81	99.71	0.000241	32.04	93.02
616								
	765.40	1	1.20	0.29	100.00	0.000053	6.98	100.00
872								
	1081.94	0	0.00	0.00	100.00	0.000000	0.00	100.00
1232								
	1529.50	0	0.00	0.00	100.00	0.000000	0.00	100.00
1742								

1- Calculation made by converting size range limits to volumes and obtaining the mean volumetric diameter.
2- Calculation based on the distribution of the total population, sized from 10 collection cards.
3- Mass in micrograms Malathion, calculated using the volumetric mean diameter and 1.23 gm/cm^3 density Malathion.

TABLE 16. Measured and calculated droplet size characteristics of aerially applied baited malathion from flagged sites during spray week 6 beginning August 24, 1981.

SIZE RANGE LIMIT (microns)	VOLUMETRIC MEAN DIAMETER[1] (microns)	TOTAL NUMBER DROPLETS	DROPLET DENSITY[2] (NO./FT^2)	PERCENT NUMBER	CUMULATIVE PERCENT NUMBER	CALCULATED MASS MALATHION[3]	CALCULATED PERCENT MASS	CUMULATIVE PERCENT MASS
35								
	40.62	0	0.00	0.00	0.00	0.000000	0.00	0.00
45								
	50.50	9	8.31	2.37	2.37	0.000000[4]	0.01	0.01
55								
	69.74	43	39.69	11.32	13.68	0.000002	0.10	0.10
80								
	100.54	44	40.62	11.58	25.26	0.000005	0.29	0.40
115								
	147.62	91	84.00	23.95	49.21	0.000034	1.91	2.31
170								
	210.81	97	89.54	25.53	74.74	0.000107	5.94	8.24
240								
	282.48	47	43.38	12.37	87.11	0.000124	6.92	15.17
315								
	385.00	20	18.46	5.26	92.37	0.000134	7.46	22.62
436								
	540.97	4	3.69	1.05	93.42	0.000074	4.14	26.76
616								
	765.40	25	23.08	6.58	100.00	0.001314	73.24	100.00
872								
	1081.94	0	0.00	0.00	100.00	0.000000	0.00	100.00
1232								
	1529.50	0	0.00	0.00	100.00	0.000000	0.00	100.00
1742								

1- Calculation made by converting size range limits to volumes and obtaining the mean volumetric diameter.
2- Calculation based on the distribution of the total population, sized from 13 collection cards.
3- Mass in micrograms Malathion, calculated using the volumetric mean diameter and 1.23 gm/cm^3 density Malathion.
4- Depicts a value smaller than 0.0000005 micrograms mass or 0.005 percent.

TABLE 17. Measured and calculated droplet size characteristics of aerially applied baited malathion from flagged sites, average of spray weeks 1-6 beginning July 14, 1981.

SIZE RANGE LIMIT (microns)	VOLUMETRIC MEAN DIAMETER[1] (microns)	TOTAL NUMBER DROPLETS	DROPLET DENSITY[2] (NO./FT^2)	PERCENT NUMBER	CUMULATIVE PERCENT NUMBER	CALCULATED MASS MALATHION[3]	CALCULATED PERCENT MASS	CUMULATIVE PERCENT MASS
35								
	40.62	0	0.00	0.00	0.00	0.000000	0.00	0.00
45								
	50.50	9	1.64	0.57	0.57	0.000000[4]	0.00[4]	0.00[4]
55								
	69.74	140	25.45	8.88	9.45	0.000006	0.11	0.12
80								
	100.54	236	42.91	14.97	24.43	0.000028	0.57	0.68
115								
	147.62	396	72.00	25.13	49.56	0.000149	3.02	3.70
170								
	210.81	351	63.82	22.27	71.83	0.000385	7.79	11.49
240								
	282.48	239	43.45	15.16	86.99	0.000631	12.76	24.26
315								
	385.00	135	24.55	8.57	95.56	0.000903	18.26	42.51
436								
	540.97	41	7.45	2.60	98.16	0.000761	15.38	57.89
616								
	765.40	26	4.73	1.65	99.81	0.001367	27.62	85.52
872								
	1081.94	2	0.36	0.13	99.94	0.000297	6.00	91.52
1232								
	1529.50	1	0.18	0.06	100.00	0.000419	8.48	100.00
1742								

1- Calculation made by converting size range limits to volumes and obtaining the mean volumetric diameter.
2- Calculation based on the distribution of the total population, sized from 66 collection cards.
3- Mass in micrograms Malathion, calculated using the volumetric mean diameter and 1.23 gm/cm^3 density Malathion.
4- Depicts a value smaller than 0.0000005 micrograms mass or 0.005 percent.

decrease in the proportion of large particle sizes in the flagged areas may be an artifact of the disparity in sample size.

Two independent experiments utilizing Cascade Impactors and Hi Vol samplers were performed in an attempt to quantify the proportion of droplets in the respirable size range. The absence of detectable levels from these experiments complement the monitoring data presented in Tables 4 - 17 where the numbers of droplets in the smaller size ranges decreased dramatically and one would not expect to find significant numbers of droplets below the 35 μ minimum size limitation.

6.6 Results: Within and Between Cell Variation

The mass fallout of baited malathion proved to be highly variable for each spray. The statistical comparison of within cell variability sampled by eight replicates per cell versus two replicates conducted during spray week 2 was not significant (Table 18). Further comparison of cell variability indicated that the mass fallout was uniformly variable and no one cell or group of cells differed from the others.

6.7 Results: Mass Fallout Degradation

Results from the mass fallout degradation of malathion are presented below:

No. of Days After Spray	Conc. of Malathion on Teflon Sheets
1	1148.12 $\mu g/ft^2$
2	911.50 $\mu g/ft^2$
3	633.75 $\mu g/ft^2$
4	506.50 $\mu g/ft^2$
5	187.50 $\mu g/ft^2$

This study was carried out during spray week 2. One can see that a half life of the mass fallout deposition can be estimated to be roughly 3 days. This rate approximates published values for malathion degradation on citrus (3,4). Degradation of malathion on reactive surfaces such as soil and vegetative material may under certain conditions be expected to occur at an accelerated rate due to the presence of microbial populations. The non-reactive Teflon surface was selected to eliminate the effect of microbial populations. These results should not be viewed as representative of what might occur under all possible conditions.

6.8 Results: Relationship of Mass Fallout Deposition and Malathion Water Concentration

This phase of the study was established to verify the association between mass deposition of malathion and potential water contamination. A series of five independent experiments was carried out to quantify the association. The following results were obtained:

Water (µg/ℓ)	Actual Mass Deposition	Theoretical Mass Dep.
310	860 µg/ft^2	620 µg/ft^2
626	1440 µg/ft^2	1252 µg/ft^2
326.5	1100 µg/ft^2	653 µg/ft^2
592.7	1120 µg/ft^2	1185 µg/ft^2
83.5	194 µg/ft^2	167 µg/ft^2

Theoretical mass deposition was calculated from the total malathion extracted from the 4 liters of water in the Teflon container. This value was divided by 2 (2 ft^2 surface area) to estimate deposition per ft^2. A

Table 18. Mass Deposition Comparisons Within and Among Geographic Cells

I. Within Cell Comparison

2 per cell (ug/ft^2)	8 per cell (ug/ft^2)
350	3,240
3,000	44
	714
	4,485
	3,480
	50
	2,059
	data lost

Unpaired students t = 0.26 (not significant)

II. Among Cell Comparison

Sources of Variation	df[1]	SS[2]	MS[3]	F
Cells	22	1.2840E8[4]	5.8365E6	0.93
Rep/Cell	23	1.4389E8	6.2562E6	
Total	45	2.7229		

F value 0.93 is not significant

1) df = Degrees of freedom
2) SS = Sums of Squares
3) MS = Means Square
4) Scientific notation denoting movement of the decimal 8 places to the right (e.g. 1E4 = 10000)

comparison of values for actual deposition and theoretical deposition revealed how close the data sets were. With the exception of one pair of data points, the columns are virtually identical, much closer than one would expect considering the variation documented in the mass deposition section of results.

A simple linear model was calculated to describe the relationship of deposition to water concentration (fixed volume of 4 liters).

$$Y = 23.53 + 0.436\ (X)$$

Where: Y = concentration malathion ($\mu g/\ell$) in water

X = mass deposition ($\mu g/ft^2$)

The model has a correlation coefficient of .906 and a coefficient of determination of .821. It is presented only for descriptive purposes and should not be utilized beyond the range of mass deposition presented above and relates only to a fixed volume of 4 liters.

7. ENVIRONMENTAL MONITORING OF AERIAL SPRAYS: AIR MONITORING

7.1 Materials and Methods: Air Monitoring

The number of air monitoring locations was derived from a pre-spray survey of populations of hospitals, schools, nursing homes and private residences within the study area. While it was immediately apparent that EHAP did not have sufficient instrumentation and resources to adequately sample this enormous area, the decision was made to allocate air sampling instruments in proportion to the various populations to allow rough comparisons to be made. The proportionate characterization of the study area was considered to be more representative than arbitrary selection of air sampling sites. Based upon the pre-spray survey, the following air sampling proportions were selected: 30 private residences; 11 schools; 2 hospitals and 2 nursing homes. At each sampling site both inside

and outside levels of malathion in air were monitored. The total of all locations would exhaust the instrument inventory of the program.

All air samplers utilized electric timers to standardize sampling periods. Samples were taken according to the following schedule:

1. Background - 24 hrs before spray
2. Spray - 6 to 9 hrs during spray
3. Post-spray - 24 hrs after spray
4. Post-spray - additional 24 hr period

Low volume air samplers (Lo Vol) were utilized to monitor private residences. Each sampler consisted of a carbon-vaned pump pulling air through a critical orifice to establish a standard flow. The air flow was directed through a 19 mm o.d. x 17 cm long glass sampling tube containing a 10 cm long bed of amberlite XAD-2 polystryrene-divinylbenzene resin (Rohm and Haas). The glass sampling tube was held in place with a Cajon Ultra Torr adaptor modified to accept a Swagelock hose connector. Two of these sample holders were connected by means of two 10 ft lengths of Tygon tubing and a Y fitting to provide the capability of sampling both the inside and outside of a structure simultaneously. The Lo Vol sampler was located outside a residence and one sample holder was anchored with a metal rod to elevate it above the ground. The second sample holder was brought into the interior of the residence through a window and anchored inside. Window openings were sealed and weatherized using foam strips. When energized, the pump was calibrated to draw 15 liters of air per minute simultaneously through each sampling tube in the interior and exterior of the residence.

Modified General Metal Works high volume samplers (Hi Vol) equipped with Kurz Instruments constant flow controllers were utilized both inside and outside of hospitals and nursing homes. Samplers originally allocated to schools were

reassigned to hospitals and nursing homes since the sampling period occurred during the summer recess. Hi Vol flow rates were calibrated at 25 cubic feet per minute. The Hi Vol flow was drawn through glass cartridges adapted for packing with pre-cleaned XAD-2 macroreticular resin, an adsorbent material used for trapping organic materials. The collection efficiency of the Hi Vols was 100%. Two Hi Vols were utilized at each location, one to monitor interior air concentrations and another to monitor outside air concentrations.

All Lo Vol and Hi Vol samples were stored on dry ice immediately after collection, as well as prior to, and during, shipment to the Chemistry Laboratory in Sacramento. All samples were kept frozen until they were analyzed.

Extractions and analyses were performed at the Chemistry Laboratory in Sacramento. The XAD-2 resin and foam retaining pad were transferred from the sampling jar into a 500 ml amber bottle which had been fitted with a Teflon-lined lid. About 375 ml of a 75:25 hexane/acetone (V/V) mixture was added to the jar. The sealed jar was placed in an ultrasonic bath for 1 hour. The solvent mixture was then decanted into a Buchner funnel and filtered with suction through Whatman #1 filter paper. An additional 300 ml of the solvent mixture was then added to the resin remaining in the bottle and the sealed bottle was again placed in the ultrasonic bath for 20 minutes. After 20 minutes the solvent, resin, and foam pad were transferred to the Buchner funnel.

The resin and foam were rinsed twice with 75 ml aliquots of the solvent mixture. The resulting filtrate was collected with suction and evaporated to near dryness on a roto-evaporator. The resulting volume was made up to a final volume of 10 ml with ethyl acetate. An aliquot of the 10 ml sample was analyzed by GC utilizing a flame photometric detector (phosphorous mode) and a 6 ft long, 3% SP 2100 on Chromosorb AWDS column.

7.2 Results: Air Monitoring

Air monitoring instruments were established in flagged areas which were to be avoided by the aerial spray and in areas which were sprayed directly. All hospital monitoring sites were not to be sprayed and were thus categorized as flagged areas. Nursing/convalescent homes and private residences were categorized as non-flagged since they were smaller and were located throughout the area that could not be avoided. These sites were directly sprayed by the aerial applications as were all other structures in the eradication area.

The air monitoring results included values of both malathion and malaoxon, the principal oxidation product of the parent material. All malaoxon values are corrected for instrument oxidation (Table 19). Data calculations converted total mass of material collected to a concentration in terms of $\mu g/m^3$ of air.

Air monitoring data represent time-weighted averages. The background 24 hour post spray and second 24 hr post spray periods were of equal duration and are therefore directly comparable. The spray period was limited to a 6 to 9 hour monitoring period and therefore cannot be directly compared to other periods of different duration. Additionally, data values presented represent absolute values pertinent to exposure studies since background levels were not subtracted.

Air monitoring data for nursing/convalescent homes and private residences are presented in Figures 12-15. Figures 12 and 13 depict malathion levels and Figures 14 and 15 malaoxon levels. Each figure plots mean air values for each spray and additionally the mean of the cumulative sprays. All malathion and malaoxon levels remained at extremely low values throughout the six spray period. Measured malathion values never exceeded 1 $\mu g/m^3$, well within the parts per trillion (V/V) range. Malaoxon values typically ranged from 1 to 2 orders of magnitude below the malathion and never exceeded 0.1 $\mu g/m^3$. Air concentrations

Table 19. Air monitoring instrument oxidation efficiencies converting malathion to malaoxon.

Instrument	Sampling duration (hr)	Flow rate	Oxidation efficiency (%)	No. samples in calculation
HiVol[1]	24	40CFM[2]	21.8[3]	3
HiVol	24	25CFM	15.7	4
HiVol	2	25CFM	0.0	4
HiVol	2	40CFM	0.0	2
LoVol[4]	24	15LPM[5]	9.0	4
LoVol	2	15LPM	0.0	4

1. High volume air sampler
2. CFM - cubic feet per minute
3. Mean value of the number of samples in the adjacent column
4. Low volume air sampler
5. LPM - liters per minute

of both malathion and malaoxon monitored inside structures were always lower than outside values. Additionally, no trends toward accumulating levels were obvious during the six spray period. This was best demonstrated by monitored background air concentrations taken before each spray. With the exception of the first background value taken before the initial spray, no significant increasing trend in air concentrations was discerned. This absence of a trend was not quite as clear cut with malaoxon values. However, these results were orders of magnitude below the range of the malathion values and exhibited larger standard of the mean. The variation observed in the malaoxon data would make it difficult to establish any significant trend.

Many of the malaoxon values measured during the spray periods are extremely low because the adjustment for instrument oxidation is a significant fraction of the small mass collected during the 6 to 9 hour spray period. The combination of these factors caused a proportionally greater increase in the malaoxon concentrations calculated for the spray periods than for the 24 hour monitoring periods.

Air monitoring results from hospitals in flagged areas were very similar to data from non-flagged areas. Malathion and malaoxon values were within the same relative concentration ranges and again failed to show a significant trend towards accumulation (Figures 16 and 17). This was not unexpected since one would predict that vapor from the surrounding area would enter the flagged areas. Air concentrations were again extremely low, typically in the parts per trillion range. A summary of the cumulative statistics for malathion and malaoxon for the six spray period is shown in Tables 20-22.

8. ENVIRONMENTAL MONITORING OF AERIAL SPRAYS: WATER MONITORING

8.1 Materials and Methods: Water Monitoring

Water monitoring was performed in cooperation with the California Department

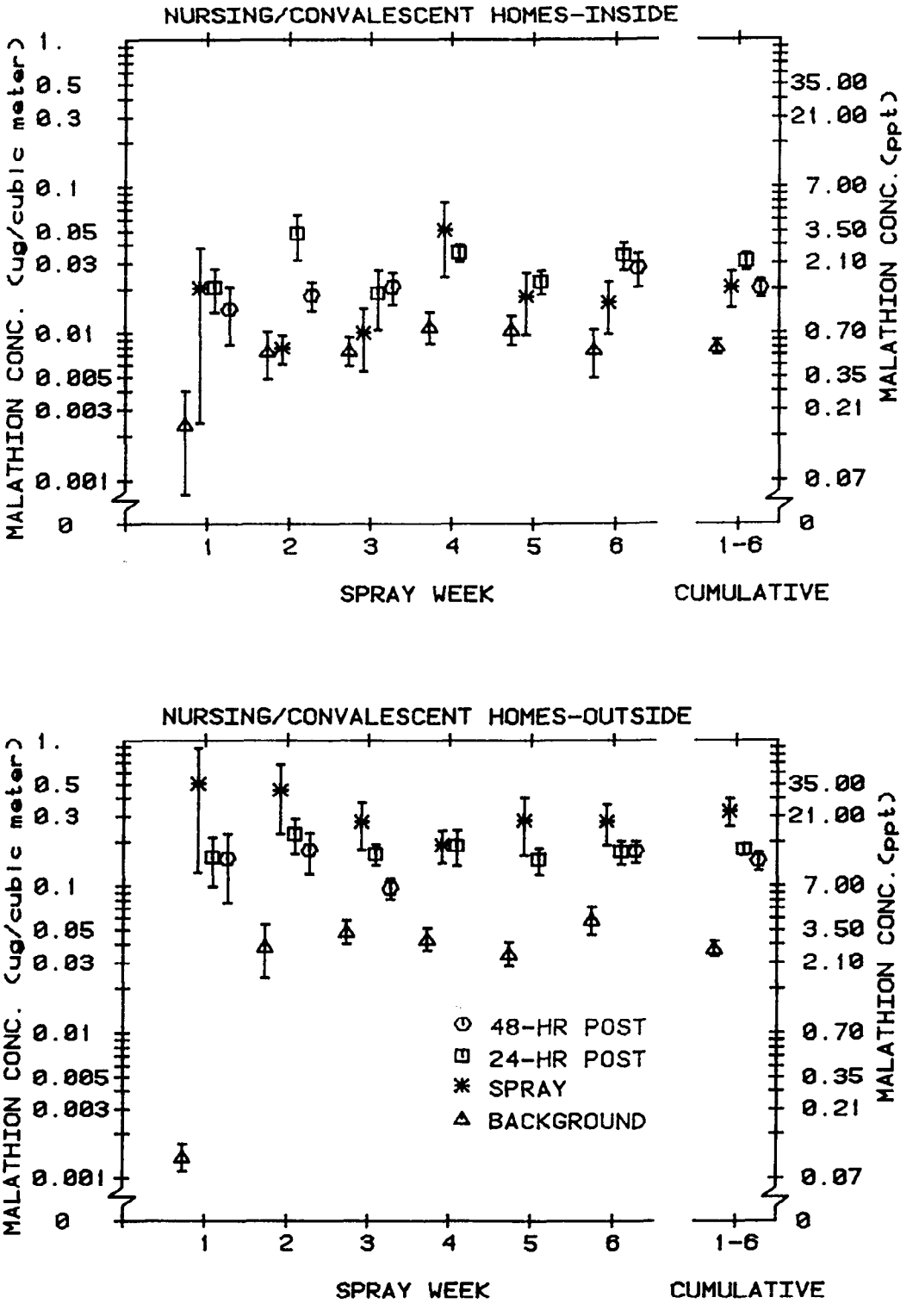

Figure 12. Mean air concentrations and standard error of the means of malathion monitored from inside and outside of nursing/convalescent homes during a 24 hr. background period, a 6-9 hr. spray period, a 24 hr. post-spray period and a second 24 hr. post-spray period for each spray week and the average of 6 spray weeks. The symbol key is presented in the bottom figure.

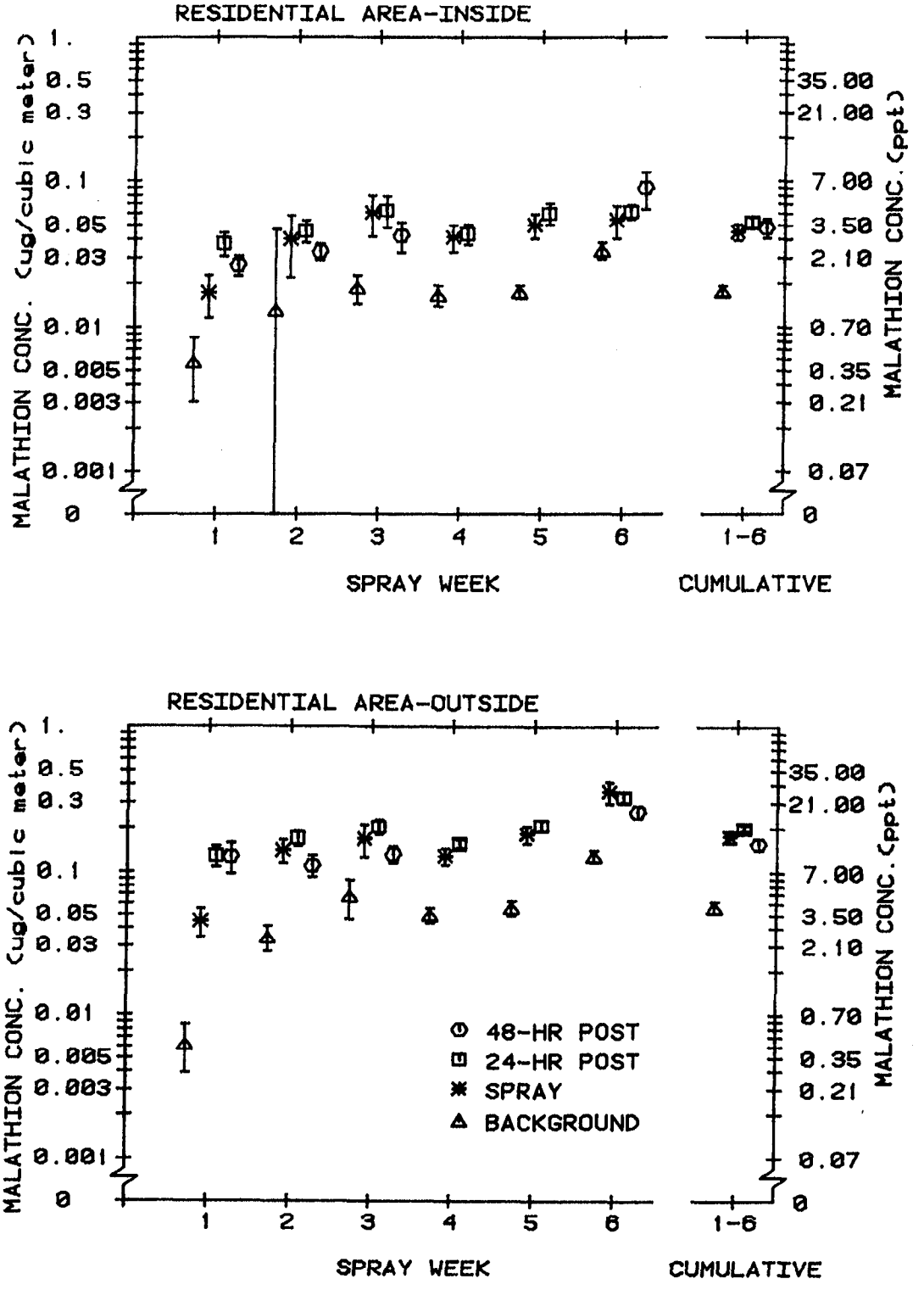

Figure 13. Mean air concentrations and standard error of the means of malathion monitored from inside and outside of private residences during a 24 hr. background period, a 6-9 hr. period, a 24 hr. post-spray period and a second 24 hr. post-spray period for each spray week and the average of 6 spray weeks. The symbol key is presented in the bottom figure.

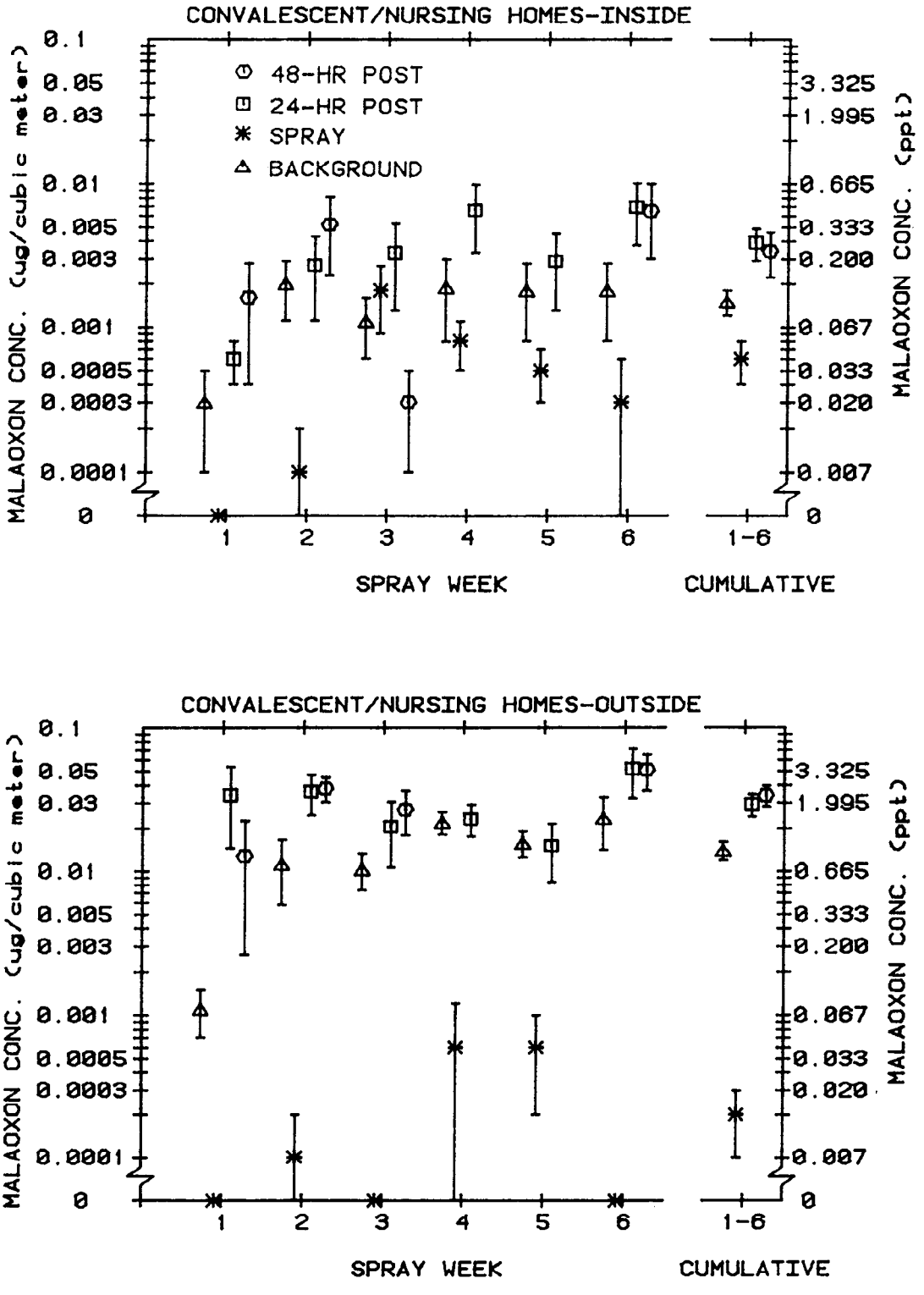

Figure 14. Mean air concentrations and standard error of the means of malaoxon monitored from inside and outside of convalescent/nursing homes during a 24 hr. background period, a 6-9 hr. spray period, a 24 hr. post-spray period and a second 24 hr. spray period for each spray week and the average of 6 spray weeks. The symbol key is presented in the top figure.

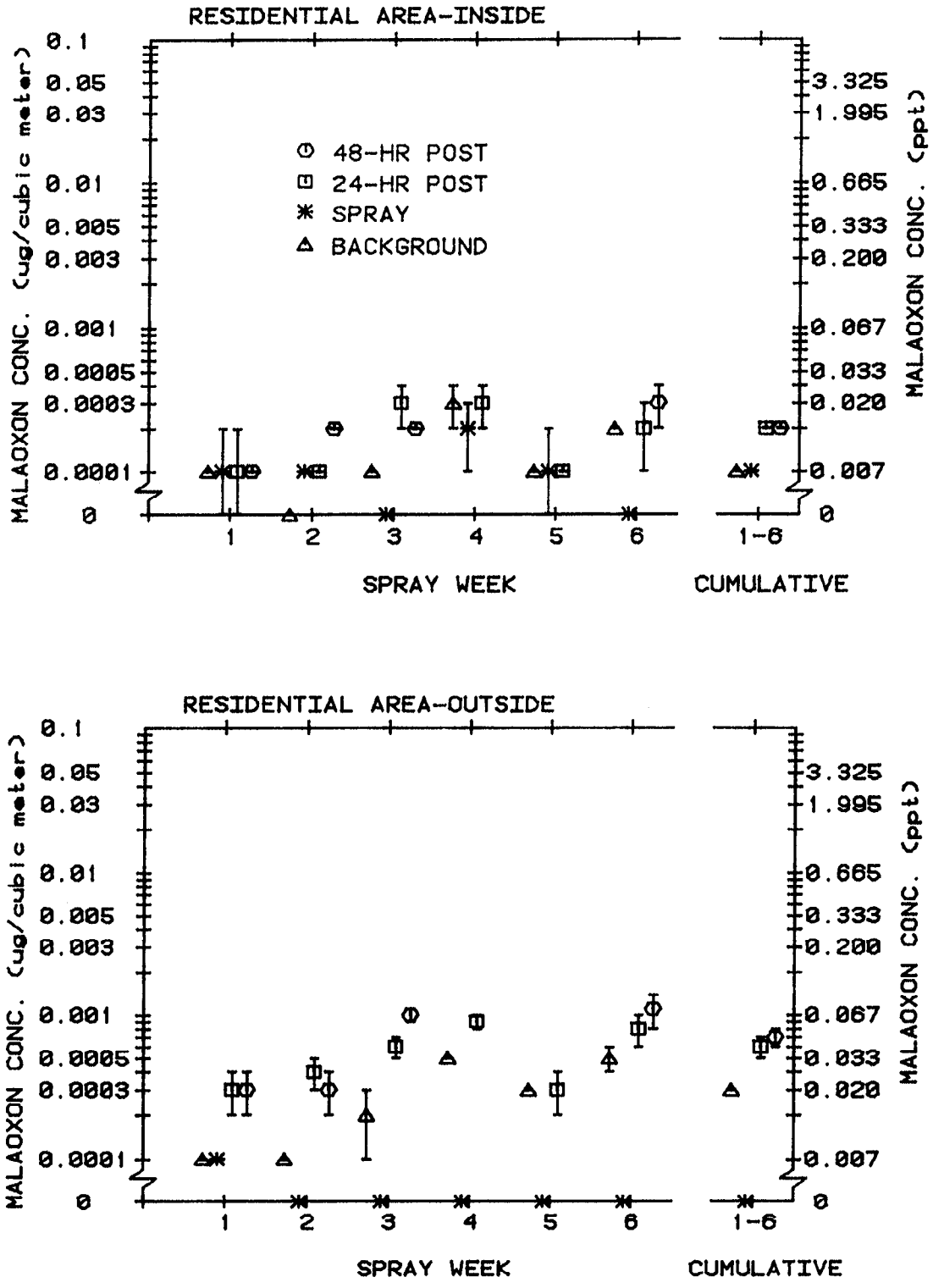

Figure 15. Mean air concentrations and standard error of the means of malaoxon monitored from inside and outside of private residences during a 24 hr. background period, a 6-9 hr. monitoring period, a 24 hr. post-spray period and a second 24 hr. post-spray period for each spray week and the average of 6 spray weeks. The symbol key is presented in the top figure.

of Fish and Game (CDFG). The EHAP responsibilities were confined to monitoring inland water bodies, both natural and man-made, occuring within the study area. These were classified in the following categories:

1. Man-made water bodies excluding swimming pools
2. Swimming pools
3. Natural water bodies
4. Reservoirs

Water sampling utilized two replicate samples collected in 1 liter amber glass bottles filled to capacity and sealed with caps lined with Teflon film. In special cases where large water bodies were being sampled, up to 10 replicate samples were drawn. Each water sampling site was sampled before sprays for a background level then sampled again after the spray to determine the elevated pesticide level. In a few special instances, a serial sampling scheme was undertaken to provide insight into degradation rates. Some special sampling did occur beyond the sixth spray week in order to complete the objectives of the study protocol. After samples were drawn they were stored on ice in portable chests and shipped to the Chemistry Laboratory in Sacramento for analysis.

An 800 milliliter aliquot of a water sample was extracted three times with fresh 50 ml aliquots of methylene chloride. The three methylene chloride extraction volumes were combined and filtered through calcium sulfate to remove traces of water. The filtrate was collected and evaporated to near dryness on a steam bath. The resulting residue was collected in hexane and diluted to a volume of one milliliter. An aliquot of the hexane mixture was analyzed on a GC utilizing a 10% or 20% on chromosorb AWDS column 6 ft in length. The GC utilized a Thermionic Specific Detector.

8.2 Materials and Methods: Drainage Systems

This phase of the monitoring study was, of necessity, delayed into the fall

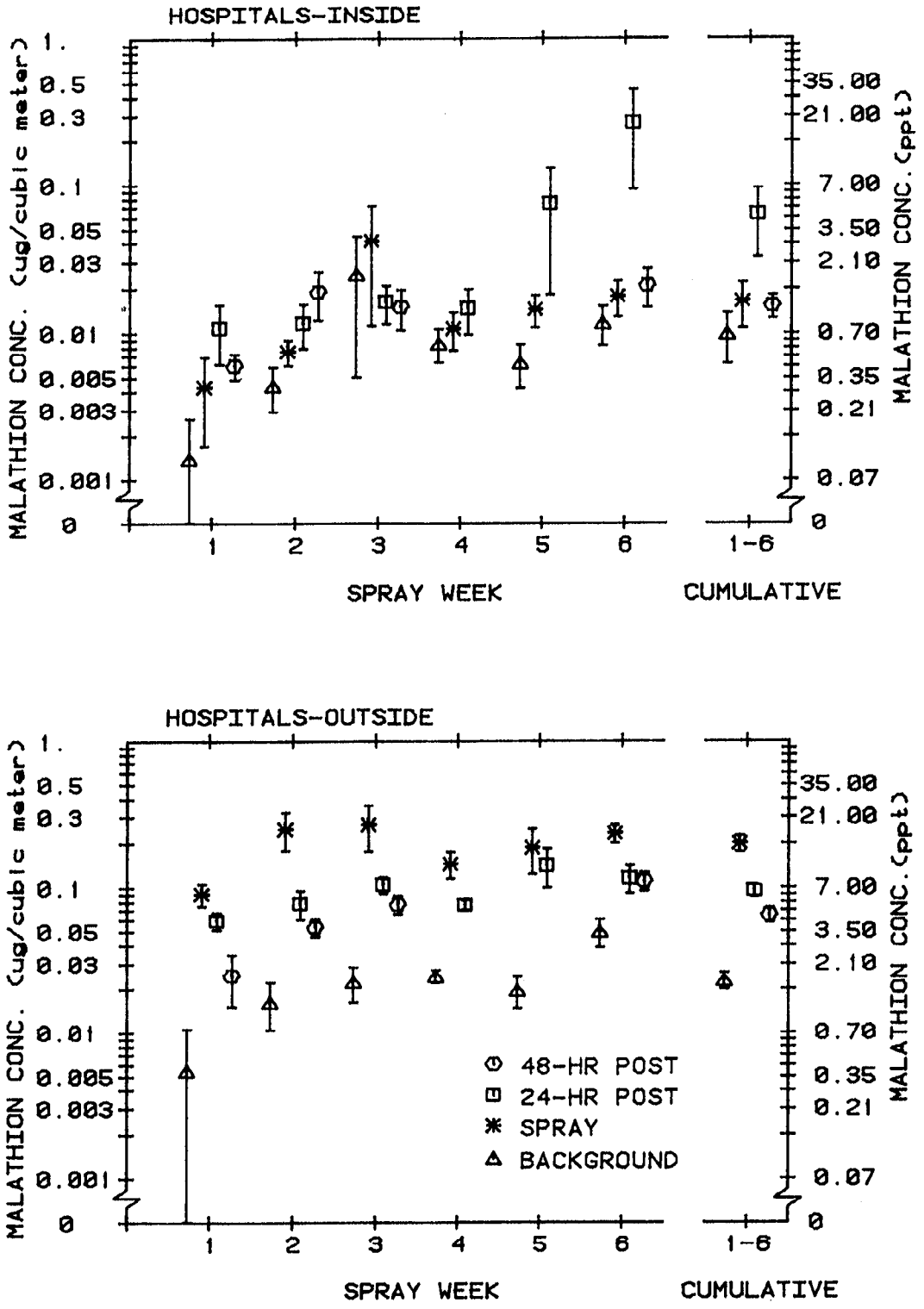

Figure 16. Mean air concentrations and standard error of the means of malathion monitored from inside and outside of hospitals during a 24 hr. background period, a 6-9 hr. spray period, a 24 hr. post-spray period and a second 24 hr. post-spray period for each spray week and the average of 6 spray weeks. The symbol key is presented in the bottom figure.

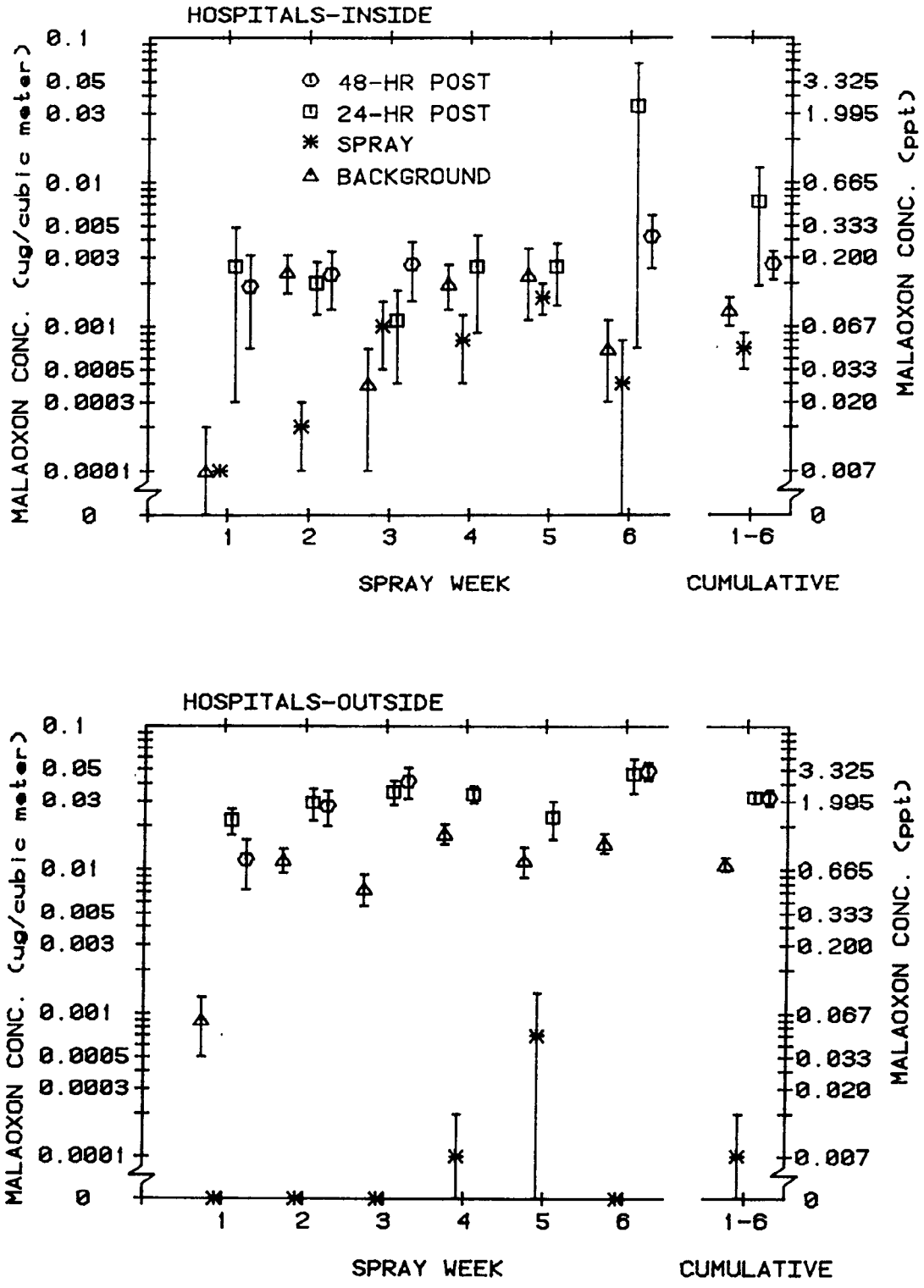

Figure 17. Mean air concentrations and standard error of the means of malaoxon monitored from inside and outside of hospitals during a 24 hr. background period, a 6-9 spray period, a 24 hr. post-spray period and a second 24 hr. post-spray period for each spray week and the average of 6 spray weeks. The symbol key is presented in the top figure.

Table 20. Average malathion and malaoxon air monitoring results from nursing/convalescent homes for 6 spray weeks.

		Monitoring Period			
		Background	Spray	24-Hour Post	Second 24-hour Post
Malathion Inside	N	39	39	39	24
	$\overline{X}$	0.0080	0.0205	0.0308	0.0202
	SE	0.0010	0.0058	0.0043	0.0029
	R	0 to 0.021	0 to 0.190	0 to 0.150	0 to 0.056
Outside	N	38	38	38	24
	$\overline{X}$	0.0376	0.3232	0.1774	0.1475
	SE	0.0046	0.0693	0.0179	0.0218
	R	0 to 0.100	0.008 to 2.023	0.015 to 0.437	0.024 to 0.433
Malaoxon Inside	N	39	39	39	24
	$\overline{X}$	0.0015	0.0006	0.0039	0.0034
	SE	0.0003	0.0002	0.0010	0.0012
	R	0 to 0.0073	0 to 0.0067	0 to 0.0233	0 to 0.0209
Outside	N	38	38	38	24
	$\overline{X}$	0.0139	0.0002	0.0292	0.0337
	SE	0.0021	0.0001	0.0050	0.0056
	R	0.004 to 0.0516	0 to 0.0040	0 to 0.1430	0 to 0.1020

N=number of samples; $\overline{X}$=mean values; SE=standard error of mean; R=range

Table 21. Average malathion and malaoxon air monitoring results for private residences for 6 spray weeks.

		Monitoring Period			
		Background	Spray	24-hour Post	Second 24-hour Post
Malathion Inside	N	140	141	140	90
	$\bar{X}$	0.0176	0.0448	0.0519	0.0476
	SE	0.0015	0.0057	0.0040	0.0072
	R	0 to 0.104	0 to 0.391	0 to 0.403	0.004 to 0.585
Outside	N	143	142	141	91
	$\bar{X}$	0.0565	0.1741	0.1998	0.1550
	SE	0.0054	0.0161	0.0097	0.0125
	R	0 to 0.529	0 to 1.332	0.019 to 0.598	0.010 to 0.627
Malaoxon Inside	N	140	141	140	90
	$\bar{X}$	0.0001	0.0001	0.0002	0.0002
	SE	0.0000	0.0000	0.0000	0.0000
	R	0 to 0.0017	0 to 0.0015	0 to 0.0016	0 to 0.0014
Outside	N	143	142	141	91
	$\bar{X}$	0.0003	0.0000	0.0006	0.0007
	SE	0.0000	0.0000	0.0001	0.0001
	R	0 to 0.0021	0 to 0.0005	0 to 0.0042	0 to 0.0046

N=number of samples; $\bar{X}$=mean value; SE=standard error of mean; R=range

Table 22. Average malathion and malaoxon air monitoring results for hospitals for 6 spray weeks.

		Monitoring Period			
		Background	Spray	24-hour Post	Second 24-hour Post
Malathion Inside	N	44	44	43	29
	$\bar{X}$	0.0099	0.0164	0.0635	0.0153
	SE	0.0037	0.0057	0.0314	0.0028
	R	0 to 0.164	0 to 0.252	0.002 to 1.213	0 to 0.058
Outside	N	44	45	42	31
	$\bar{X}$	0.0229	0.1996	0.0955	0.0649
	SE	0.0031	0.0256	0.0092	0.0078
	R	0 to 0.096	0.009 to 0.720	0.005 to 0.303	0 to 0.155
Malaoxon Inside	N	44	44	43	29
	$\bar{X}$	0.0013	0.0007	0.0073	0.0027
	SE	0.0003	0.0002	0.0054	0.0006
	R	0 to 0.0086	0 to 0.0036	0 to 0.2319	0 to 0.0098
Outside	N	44	45	42	31
	$\bar{X}$	0.0109	0.0001	0.0320	0.0317
	SE	0.0012	0.0001	0.0032	0.0044
	R	0 to 0.0278	0 to 0.0047	0 to 0.1025	0 to 0.1049

N=number of samples; $\bar{X}$=mean; SE=standard error of mean; R=range

of 1981 when significant precipitation occurred. Water sampling methodology previously described in the water sampling section was utilized to sample both main drainage channels and subsystem inlets into the main channels. The large areas of asphalt and concrete paving in the Santa Clara Valley provided an enormous surface area for mass fallout deposition. This would provide a large amount of water soluble baited pesticide to be extracted by rain water and concentrated in the drainage systems.

A natural watershed, more specifically a riparian habitat in San Mateo County, was also monitored by sequential sampling over time during a period of precipitation. This study was conducted to provide a data base to evaluate run-off levels from natural media.

8.3 Results: Water Monitoring

Only water monitoring results from CDFA locations specified in the monitoring protocol (Appendix I) are presented in this section. Results from the cooperative monitoring with CDFG will be presented in their report on the impact of the aerial spray on aquatic habitats.

Water samples were taken from flagged reservoirs within the spray area and reservoirs physically outside the boundaries of the spray area that were of concern because of their immediate proximity to the spray area (Figure 18). The individual sprays resulted in malathion concentrations significantly higher than background levels (Figure 18) although actual levels were relatively low with a peak concentration of 32 ppb monitored from a reservoir within the spray area. Levels monitored in other spray weeks never approached this value. Statistics summarizing each spray for both malathion and malaoxon are presented in Appendix VI. The number of positive malaoxon samples was too small for meaningful graphic presentation. In all cases, pesticide levels in reservoirs were reduced by the time background samples were taken for the next spray week and no evidence of

the accumulation of the pesticide was observed.

Malathion concentrations in man-made water bodies excluding swimming pools were elevated significantly above their respective background levels by the aerial spray (Figure 19). The same pattern of fluctuation described for reservoirs was observed. Malathion concentrations increased during and immediately after a spray then subsequently declined only to be elevated by the next spray. Samples from man-made water bodies contained the second highest concentrations of malathion found in water and a significant numbef of these samples contained malaoxon (Appendix VI). The highest value of 170 ppb was taken from a water hazard on a golf course. Reflecting pools and shallow fountains containing pool cleaning chemicals were often found to contain malaoxon in the absence of malathion due to the rapid oxidation of malathion to the oxon form by the pool chemicals. Concentrations of malathion in water samples were generally found to be very low averaging 10.5 ppb over the six spray period.

Swimming pools in the spray area were of concern because of possible human exposure. Monitoring results, however, showed that malathion concentrations in pools were the second lowest category, only higher than reservoirs (Figure 18). The highest recorded sample was 23 ppb malathion and the six spray average for pools was 0.89 ppb malathion (Appendix VI). As expected, the chemicals used in swimming pools efficiently oxidized the malathion to malaoxon resulting in 49 instances where detectable levels of malaoxon were documented. These concentrations were transient and degraded to extremely low or non-detectable levels within hours. The degradation was accelerated in the presence of sunlight. The following serial sampling data was taken from a chlorinated pool during a single bright day with abundant sun but with early morning fog:

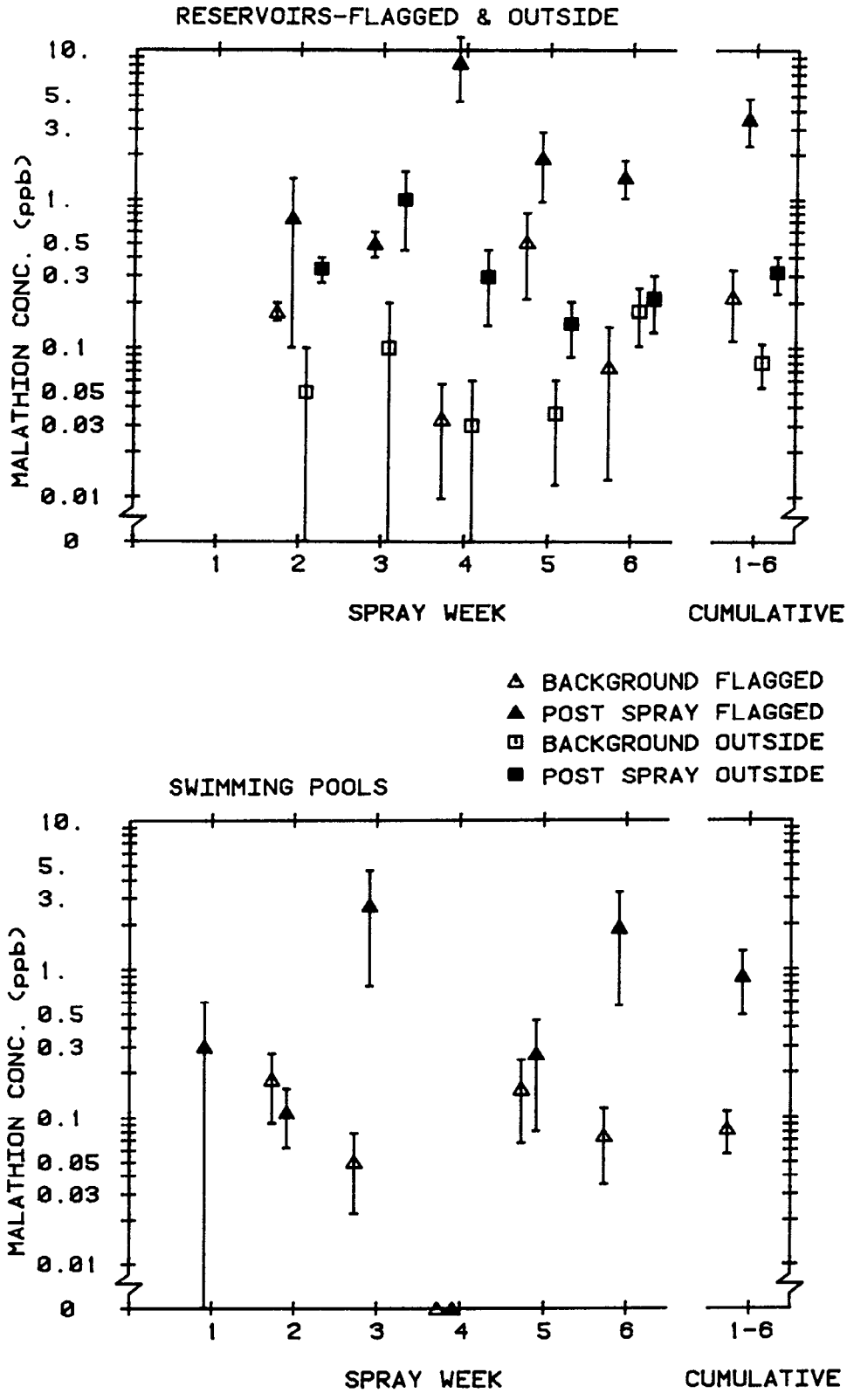

Figure 18. Mean water concentrations and standard error of the means for malathion monitored from reservoirs and swimming pools for each spray week and the average of 6 spray weeks. Open symbols denote background samples taken before sprays and dark symbols denote samples taken immediately after sprays.

Time	Malaoxon (ppb)
0125	3.5
0930	3.1
1930	0.0

Natural water bodies describes a catch all category including a few flowing streams, dry stream beds with stagnant pools, percolation ponds and other small lakes and basins. Not surprisingly, the data for these water bodies is extremely variable with standard errors of the means larger than the mean values. The monitoring data from natural water bodies within the spray area contained the highest malathion level, 703 ppb, in water taken from a shallow stagnant pool in a dry stream bed. Several high values scattered throughout the six spray data set heavily influenced the mean value of 26.75 ppb (Figure 19). Concentrations from monitoring locations outside the spray area were much lower, averaging 0.93 ppb for spray samples over the 6 week period. Detailed data summaries are presented in Appendix VI.

The predictability of malathion and malaoxon concentrations in water based on mass fallout deposition data has already been established in the mass fallout section of this report. Results from the water monitoring tend to confirm the implied characteristics of those water bodies most susceptible to high levels of pesticide. In almost every instance, those water bodies with a high surface area and relatively small volume contained the highest levels of pesticide. This generalization must be tempered, however, with the high variability of the mass deposition. Geographical areas exposed to high mass deposition would generally contain higher levels of water contamination than areas impacted by low mass deposition.

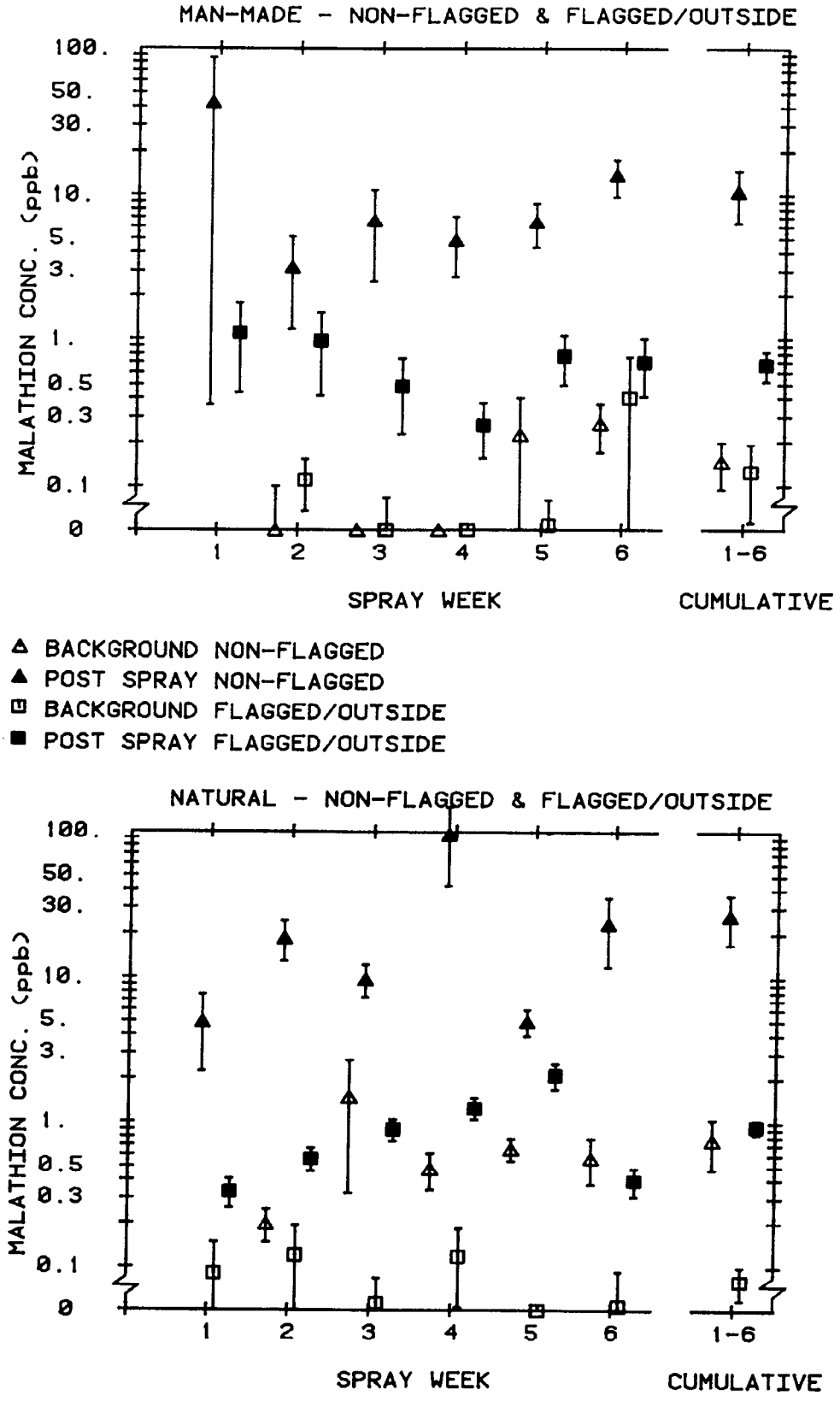

Figure 19. Mean water concentrations and standard error of the means for malathion monitored from man-made and natural water bodies for each spray week and the average of spray weeks. Open symbols denote background samples taken before sprays and dark symbols denote samples taken immediately after sprays.

8.4 Results: Drainage System

One characteristic of the large urban area that caused major concern was the immense surface area covered by asphalt or concrete. Theoretically, this impervious surface could trap the baited malathion and maximize extraction by rains, thereby concentrating and channeling high concentrations of the pesticide in a relatively small volume of water.

Initial samples (October 10 and 11, 1981) taken during a rain from flowing creeks and a storm drain inlet, indicated that water from the storm drain inlet contained significantly more malathion than the creeks being sampled (Table 23). Levels of malathion in water decreased substantially by the following day and the storm drain no longer contributed pesticide to Adobe Creek. Adobe Creek was dry except for the inlet flow and therefore was not sampled. Unfortunately, the water samples were not analyzed for malaoxon. Because of the light rainfall and lack of malaoxon analyses, a more intensive sampling study was initiated.

Results from monitoring four sites in the Santa Clara Valley storm drainage system confirmed that the deposited pesticide was being extracted by rain and concentrated in drainage systems. The data from each site monitored documented that the concentrations of malathion and malaoxon in the storm drains were higher than levels in creeks which received their effluent (Table 24). Actual malathion and malaoxon levels in the drains were high, ranging from 142 to 583 ppb. In most cases, the contribution of the storm drain effluent was diluted by the volume of water in the stream proper. However, an illustration of the mechanism of pesticide accumulation in streams from the storm dray system can be viewed by scrutinizing the results from the two monitoring sites on Guadalupe Creek. Site 1 was located upstream near the border of the eradication zone (Cell 42).

Table 23. Malathion concentrations from runoff water in the Santa Clara Valley storm drain system, October 10 and 11, 1981.

Sample Location	Date	Malathion (ppb) $\bar{x}$[1]	Malathion (ppb) sd[2]
San Tomas Aquino Ck.	10/10/81[3]	40.0	0.00
Almaden at Canoas Garden		15.5	7.07
Los Gatos Ck.		11.9	2.68
Guadalupe Ck.		68.7	8.84
Coyote Ck.		67.5	10.60
Storm Drain on Adobe Ck.	10/10/81	97.5	17.67
San Tomas Aquino Ck.	10/11/81[4]	1.1	0.00
Almaden at Canoas Garden		5.0	7.75
Los Gatos Ck.		0.7	0.21
Guadalupe Ck.		31.0	0.00
Coyote Ck.		27.0	1.41
Storm Drain on Adobe Ck.	10/11/81	dry	

1. Mean of 2 replicate samples.
2. Standard deviation.
3. Samples taken 12 hours post-spray.
4. Samples taken 36 hours post-spray.

Table 24. Malathion and Malaoxon levels from runoff water in the Santa Clara storm drain system.[1] October 27, 1981

Sampling Location	Malathion (ppb) $\bar{x}$[2]	Malathion (ppb) sd[3]	Malaoxon (ppb) $\bar{x}$	Malaoxon (ppb) sd
I. Adobe Creek				
50 ft upstream	449.0	17.7	164.0	33.2
Drain	583.0	40.3	328.0	18.4
100 ft downstream	361.0	20.5	169.0	0.0
II. Stevens Creek				
50 ft upstream	159.0	0.0	68.0	0.0
Drain tube	434.0	73.5	147.0	4.2
150 ft downstream	156.0	23.3	68.0	0.0
III. Guadalupe Creek Site 1				
50 ft upstream	1.9	0.2	0.8	0.3
Drain tube	142.0	0.0	147.0	4.2
150 downstream	23.5	2.1	22.0	0.0
IV. Guadalupe Creek Site 2				
50 ft upstream	137.0	25.4	212.0	9.2
Drain	188.0	12.0	250.0	8.5
150 ft downstream	169.0	6.4	231.0	8.5

1. All samples taken between 2 and 3.5 hours after rain started, 6 days after the last spray.
2. Mean of 2 replicate samples.
3. Standard deviation.

Site 2 was downstream of Site 1 and located in the middle of the eradication zone (Cell 17). The results in Table 24 present a clear picture of the contribution of water from the storm drainage system to the pesticide levels in the stream. Water sampled upstream of the drain at site 1 contained very little pesticide. However, downstream the 142 ppb malathion and 147 ppb malaoxon levels in the drain effluent substantially raised stream concentrations to 23.5 ppb malathion and 22 ppb malaoxon. Site 2 results exhibit the same trends but the contribution of the single drain is less obvious because of the elevated pesticide levels in the stream. Presumably, the many drains emptying into the stream between site 1 and site 2 (about 4 miles) had increased the malathion and malaoxon levels two orders of magnitude from the levels documented upstream of the drain at site 1.

The rainfall and water monitoring in the drainage system occurred six days after the most recent spray. If the rain had occurred on the same day or the day after the spray, much higher levels of pesticide could be expected.

A natural riparian watershed on Pescadero Creek, San Mateo County, was also monitored to determine the contribution of rain runoff to the total pesticide level in the creek. The creek was being used as a water source for a small water district. The monitoring occurred during October, 1981, and results reflect a case of double spraying (Table 25). Low malathion levels existed in the background samples, probably reflecting past aerial sprays. The aerial spray of October 6, 1981, elevated malathion concentrations in the creek to 19.3 ppb. A rainfall that evening resulted in malathion levels five times higher than the spray levels and 30 times higher than the background levels. The same area was resprayed because of fears that the rain reduced the efficacy of the first

Table 25. Pescadero Creek Water Monitoring

Date	Period	Malathion (ppb) $\bar{x}$[1]	Malathion (ppb) sd[2]	Comments
10-6-81	Background	3.7	0.3	
10-6-81	Spray	19.3	9.2	Rained pm
10-7-81	18 hr post	102.0	3.5	
10-8-81	Respray			
10-9-81	18 hr post	25.0	3.5	
10-10-81	42 hr post	31.6	4.0	Light rain am
10-11-81	66 hr post	25.3	4.7	
10-12-81	90 hr post	8.1	6.5	
10-13-81	114 hr post	8.5	5.7	Light rain

1. Mean of 2 replicate samples through 10-9-81 and 3 replicate samples thereafter.
2. Standard deviation.

application. On October 10, 1981, an additional light misting rain occurred, and again elevated stream concentrations but to a lesser degree. The lower absolute concentrations detected during this monitoring, relative to the storm drain monitoring, probably reflect malathion losses into the soil. Although the scale of the runoff problem is less in the natural situation, the same trend is clear. Rain runoff concentrates available mass and deposits it into whatever sink is available.

9. DISCUSSION

The purpose of this study was to quantitatively monitor baited malathion applied aerially over the Santa Clara Valley of California. The major impacts of the sequential aerial sprays can be attributed to the direct mass fallout deposition. All exposed surfaces, independent of their composition, were impacted by a deposition of droplets between 37 to 1,750 microns in diameter and having a volumetric median diameter of between 200 to 300 microns. Although quite variable, the droplet deposition occurred at densities equivalent to an average 6 spray value of 1,385 $\mu g/ft^2$.

The average malathion mass fallout deposition of 1,385 $\mu g/ft^2$ for six sprays accounts for about 76% of the desired application. This exceeded expected values based on published data for sprays applied at lower elevations and must be attributed to large droplets characterizing the baited spray. Non-baited sprays applied at altitudes barely above plant canopies have been reported to account for 30 to 80% of the material applied (1,5,6). The total of 76% accountability of sprayed material was therefore highly efficient considering that the aerial sprays were applied from an altitude of 300 ft.

The physical characteristics of any aerial spray make quantitative mass balance of amount of material sprayed and amount deposited impossible. Small

droplets created by wind shear, turbulence and evaporation have low terminal settling velocities and are strongly affected by wind. Physical transport of the droplets in the atmosphere is primarily dependent on droplet size and ambient wind velocity. Droplet settling rate is a function of the square of the droplet diameter for diameters less than 100 microns (2). Once created, small droplets disperse and are carried away. If they travel any significant distance the dispersal is sufficient to make them undetectable by current monitoring technology. An illustration of this phenomenon can be viewed in the aircraft swath calibration data in Section 5. Downwind mass fallout deposition is characterized by smaller droplets as one travels farther downwind of the flightline. The particle monitoring cards revealed an increasing number of smaller droplets away from the flightline. However, the particle monitoring cards only monitor those droplets with sufficient mass to settle at ground level. Smaller sizes disperse to distances which far exceed the area being monitored and could easily extend miles beyond the areas used for the aircraft calibrations. In the specific case of the aerial application of baited malathion released at an altitude of 300 ft., those small droplets which were generated with small settling velocities (e.g. less than 1 cm/sec) would most probably be dispersed well beyond the eradication zone and would be so diluted as to make them impossible to detect with present technology.

The disposition of the baited malathion deposition was governed by a complex series of interrelated processes. As soon as the droplets were produced at the spray nozzle, the components with higher vapor pressure began to vaporize preferentially. Antagonistically, a surface film of viscous baited material gener-

ated from surface evaporation and crystallization acted to slow the release of the volatile materials. The processes described here occurred at different rates governed primarily by droplet size, temperature, humidity and other meteorological variables. After the droplet landed, the evolutionary processes of malathion volatilization, oxidation and biological and chemical degradation continued to alter the chemical and physical properties of the mass deposition. These processes were repeated with each spray over the course of the eradication effort.

Spray droplets striking a continuous, relatively impervious surface such as concrete or asphalt were collected and extracted most efficiently by rain water. This resulted in elevated malathion and malaoxon levels (>500 ppb) in water from the storm drainage system. The South San Francisco Bay was the ultimate recipient of the elevated pesticide levels in the rain water runoff.

Droplets deposited on soil, vegetation, and other naturally occurring porous media apparently were more subject to surface adsorbtion and were extracted less efficiently by rain. Although rain certainly washed malathion deposits off leaves, a significant portion of the aqueous solution could be expected to soak into soil. Monitoring results from Pescadero Creek appeared to corroborate this. Although the rain runoff raised malathion levels in the creek to a maximum of 100 ppb, this value was a factor of 5 below the highest pesticide value monitored in the storm drain system in the Santa Clara Valley. This evaluation must be considered qualitative since the two locations differed drastically in character.

The resultant concentration of pesticide in exposed water bodies was dependent on the surface to volume ratio of the water body and the amount of mass deposition impacting the surface. The relationship between mass deposition and water conta-

mination was established in Section 6.8. High pesticide values were generally characteristic of shallow stagnant pools in dry stream beds and shallow man-made pools and fountains. Pool cleaning chemicals, especially chlorine based compounds, oxidized malathion to malaoxon. The malaoxon degraded to undetectable levels, normally within a few hours.

Gas phase malathion and malaoxon in the air was generated from spray droplets and mass fallout deposition. The large spray area which was repeatedly treated by aerial application resulted in an elevated gas phase background concentration for both malathion and malaoxon. The eradication area was found to have detectable low levels of the pesticide in the parts per trillion range. The initial background air samples produced air concentrations in the .001 to .008 ug/m^3 range, probably reflecting residual pesticide from ground spraying efforts or normal urban use. Subsequent background air samples taken before sprays leveled off about an order of magnitude higher. The individual sprays caused temporary increases in air concentration as previously reported in the results section, but air concentrations never exceeded 1 ug/m^3, well within the parts per trillion range. Air inside structures contained lower levels of malathion and malaoxon than outside. The gas phase pesticide was detected in all areas monitored including flagged hospitals.

Monitoring results from the flagged areas indicated that the attempts to eliminate certain areas from the aerial spray were only minimally successful. Mass fallout was monitored in a significant number of flagged areas and in a few cases was of the same magnitude as non-flagged areas. Aircraft either could not shut off in time or occasionally did not identify some flagged areas.

The intensive six spray week monitoring period was followed by small scale

sampling into spray week 13 beginning October 12, 1981, to insure that monitored malathion and malaoxon levels remained within the ranges documented in the first 6 spray weeks. All samples taken were well within the documented ranges of the first 6 spray weeks and no indication of pesticide accumulation was observed. These sample values represent small sub-sampling files which are difficult to organize for presentation but are available upon request.

10. REFERENCES

1. Akesson, N.B. and M.N. Elaway. 1969. Dispersion of Agricultural Materials in Air Carrier Jets. J. Agric. Eng. Research. 14(1): 18-25

2. Beard, K.V. and H.R. Pruppacher. 1969. A Determination of the Terminal Velocity and Drag of Small Water Drops by Means of a Wind Tunnel. J. Atmos. Sci. :26

3. Nigg, H.N., J.A. Reinert, J.H. Stamper and G.E. Fitzpatrick. 1981. Disappearance of Acephate, Methamidophos, and Malathion from Citrus Foliage. Bull. Environ. Contam. Toxicol. 26: 267-272

4. Nigg, H.N., and J.H. Stamper, 1981. Comparative Disappearance of Dioxathion, Malathion, Oxydemetonmethyl and Dialifor from Florida Citrus Leaf and Fruit Surfaces. Arch. Environ. Contam. Toxicol. 10: 497-504

5. Renne, D.S. and M.A. Wolf. 1979. Experimental Studies of 2,4-D Herbicide Drift Characteristics. Agric. Meteor. 20: 7-24

6. Ware, G.W., W.P. Gerhardt and J.M. Witt. 1970. Pesticide Drift IV: On-Target Deposits from Aerial Application of Insecticides. J. Econ. Entomol. 63: 1982-1983

APPENDIX I

STUDY PROTOCOL

CONTINGENCY PLAN FOR MONITORING THE AERIAL RELEASE OF MALATHION BAIT WITHIN SANTA CLARA AND ALAMEDA COUNTIES DURING THE MEDITERRANEAN FRUIT FLY ERADICATION PROGRAM

Executive Summary

The attached protocol outlines a contingency plan for monitoring the aerial application of malathion bait in the event such an aerial release program is deemed necessary for control of the Mediterranean fruit fly.

The proposed monitoring plan will generate data in the following areas:

1. Ground concentration of the bait per square foot to determine potential human and animal exposure. (Section One, a, b, c, e)

2. Data necessary to estimate the possible gas phase exposure to malathion both within and outside private residences, schools, hospitals and nursing/convalescent homes within the release area. (Section Two)

3. Data necessary to calculate potential runoff concentrations in the event of rainfall in the release area. (Section One, a, b, e; Section Three, e)

4. Data necessary to calculate the maximum potential contamination of a water body within the release area such as swimming pools, ponds, reservoirs. (Section One, d; Section Three, a, b, c)

5. Data necessary to calculate the maximum potential exposure of aquatic life in creeks, ponds, and freshwater/saltwater estuaries. (Section Three, c, d, f)

CONTINGENCY PLAN FOR MONITORING THE AERIAL RELEASE OF MALATHION BAIT WITHIN SANTA CLARA AND ALAMEDA COUNTIES DURING THE MEDITERRANEAN FRUIT FLY ERADICATION PROGRAM

I. Objectives

To monitor the environmental fate within the treatment area of the pesticides applied during the aerial medfly eradication efforts.

II. Participants

California Department of Food and Agriculture

The medfly eradication aerial release monitoring study will be under the overall supervision of Ronald J. Oshima, Environmental Hazards Assessment Program (EHAP) (phone (714) 787-4683 or ATSS 651-4683) and will involve cooperation from units within the California Department of Food and Agriculture (CDFA) and listed cooperating agencies. Key personnel participating from EHAP-CDFA are listed below, along with their responsibilities;

Lee Neher

Responsible for supervision of the five sampling districts, study design, all technical aspects used in sampling, supervision over sample collection and dissemination of progress reports. Phone (714) 787-4684 or ATSS 651-4684.

Tom Mischke

Responsible for the selection of sampling methodology, field storage and transport of samples to the laboratory, and liaison to CDFA Chemistry Laboratory Services for questions concerning all aspects of the chemical analysis of collected samples. Phone (916) 322-2395 or ATSS 492-2395.

Cooperating State Agencies

The State Water Resources Control Board (SWRCB), the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB), and the California Department of Fish and Game (CDFG) are cooperating in the proposed monitoring. The contact people for these agencies are Dennis Corcoran (SWRCB) telephone (916) 322-9879 or ATSS 492-9879, Charlene Hasmann (SFBRWQCB) telephone (415) 464-0803 or ATSS 561-0803, and Brian Finlayson (CDFG) telephone (916) 445-0154. The SWRCB in cooperation with the SFBRWQCB and CDFG will review the aquatic

and hydrologic resources within the study area and select sites for fresh water creek, estuary/bay water, and organism sampling. All fish, shellfish and estuary/bay samples will be collected by CDFG, for subsequent analysis by the CDFA chemistry labs.

III. Monitoring Plan

The study outlined here is designed to handle a "worst case" situation. In the event that the decision is made to implement a large scale aerial release program, the study plan will be adjusted to reflect the actual boundaries of the release area. The attached map (Figure 1) outlines the geographical boundaries covered by this protocol. This area will be subdivided into five sampling districts. Designated EHAP personnel will supervise the monitoring activities in each district.

The study design will be separated into three sections: first, to quantify the distribution of spray droplets and resulting concentration per unit of area; second, to quantify the presence or absence of detectable air concentrations pre, during, and post-release. Finally, to quantify the immediate impact of the pesticide, pre and post-release, to bodies of water over time.

The study outlined will be performed during each release, up to a total of six. In the event that more than six separate releases would be required for control, a decision as to monitoring frequency would be made at that time based on the total number of bait releases anticipated.

IV. Sampling Design and Monitoring Timetables

The following is an outline and timetable for the field sampling. More detail on actual sampling methodology and expected results from this monitoring effort are presented elsewhere in this protocol.

Section One - Sampling the distribution and concentration of the aerial release.

a) Polyethylene backed absorbant paper 19½" X 34" fallout cards will be used to quantify the number of droplets and total concentration of pesticides impacting the total release area. The overall area will be divided into 45 subunits of equal geographical area. Two replicate fallout cards will be located near the center of each subunit area, spaced ¼ mile apart. All cards will be placed in exposed locations just prior to the aerial release and subsequently collected when spray activity has ceased in the area.

b) At one of the 45 subunits additional sampling will be performed to assure that two samples per subunit are an accurate representation of the subunit. In this subunit, 10 fallout cards will be distributed prior to the start of, and collected immediately following the aerial release.

c) To study particle size distribution, sampler cards (6" X 18" Kromekote Cover 65 pound paper, glossy coated both sides) will be placed in each of the 45 subunits. The sampler card will be placed adjacent to one of the fallout cards in each subunit and will be collected along with the fallout cards. The analysis of the spray droplet size distribution will be performed by Dr. Norman Akesson of the Agricultural Engineering Department at the University of California at Davis.

d) Two replicate fallout cards will be located immediately adjacent to all exposed public drinking water holding basins, bodies of water of interest, and all air sampling locations.

e) Additional fallout cards consisting of Teflon film (17" x 34") will be used to quantify the chemical breakdown of the malathion bait over time. A grid consisting of 16 fallout cards will be set out just prior to the aerial release. Two cards will be removed, using a preselected random order, at each of five intervals: 0, 24, 48, 72, 96 hours post-spray.

Section Two - Ambient air concentration of pesticide inside and outside dwellings.

Due to the logistics involved in obtaining a representative sampling of some 438,000 private residences, 476 schools, and 70+ hospitals, nursing/convalescent homes, both low volume samplers (15 l/min) and hi volume samplers (25CFM) will be employed. Low volume samplers will be employed to sample ambient air, inside and outside of 30 private residences. Hi volume samplers will operate inside and outside of 11 schools, two hospitals and two convalescent and/or nursing homes. If the aerial bait release occurs during hours when schools will not be in session, the samples allocated to schools will be redistributed to additional hospitals and nursing homes.

Section Three - Impact on existing water bodies

a) Two replicate water samples will be drawn from any exposed public drinking water reservoirs located within the study boundary prior

to release and again immediately following bait release in the area.

b) Thirteen replicate water samples will be randomly collected from an established population of 136 designated man-made water bodies prior to and immediately following the aerial release. The population of 136 will be divided into four sub-groups; pools, wading pools, ponds and lagoons, and fountains. The thirteen replicated samples will be proportionally divided between these four groups based on the population of each sub-group.

c) A shallow teflon basin will be floated on two selected bodies of water. These will also be collected soon after the aerial release in the respective areas to determine the actual concentration per volume of water.

d) Three replicated samples will be collected from the holding basins for the storm drain system, located in the estuary area of the South Bay.

e) Due to the high sensitivity of fish species to the bait, and low volume of water involved, special emphasis will be given to the Koi collection ponds at Kelly Park and the percolation basins used for trout release north of Los Gatos. Ten water samples will be drawn at both sites pre-release and again following the release.

f) Samples will be taken to determine the levels of exposure that pilots receive during the actual aerial release operation.

Section Four - Cooperative Sampling with CDFG

a) Replicate water samples will be collected by CDFA from seven sites along four fresh water surface streams. These sites will be sampled pre-release and again during the post-release period.

b) Replicate water samples will be collected by CDFG from seven sites within the So. San Francisco Bay estuary. These samples will be collected prior to the aerial release and again 24 hours after the release has been completed.

c) Two inland fish, three bay fish, and three shellfish samples will be collected by CDFG for tissue analysis.

V. Handling and Storage of Samples

All sampling media and containers will be prepared and pre-numbered at the California Department of Food and Agriculture laboratories in Sacramento. Each device or container will be shipped to the sampling sites with an accompanying Chain of Custody Record (See attachment 2). The Chain of Custody Record will be filled out by all parties handling or storing the sampling media or sample containers from the time they leave the Sacramento CDFA lab until they are returned to the lab for analysis. The Chain of Custody Record also contains an internal chain of custody record for use by the laboratory.

All samples within a given release area will be collected within one half hour of the termination of the operation and stored in the following manner until and during transport to the CDFA laboratory in Sacramento.

On Dry Ice ($-70^{o}c$)

fallout sheets
air samples
tank samples
benthic and fish tissues

On Ice ($40^{o}c$)

water samples

Once received by the CDFA laboratory, the samples will continue to be stored under the above conditions. All extracts of the samples will be stored at $-70^{o}c$. Duplicate samples sent to other laboratories for quality control analysis will also be stored and transported under the above conditions.

VI. Analysis of Samples

All samples will be analyzed for the presence of malathion, isomalathion, and maloxon by CDFA Chemistry Laboratory Services. Quality control duplicate samples will be analyzed by CDFA and SWRCB laboratories. If deemed necessary, selected samples may also be analyzed for other known

breakdown products of malathion. Approximately one percent of the total number of each type of sample collected will have duplicate analysis performed as part of the quality control program.

Sample analysis by the CDFA laboratories will be prioritized to allow for rapid access to critical data. The following number of samples will be analyzed within 24 hours of collection. The balance of the samples will be analyzed within six (6) days following application.

25% of fallout cards
100% of tank samples
40% of water samples
100% of school, hospital and convalescent/nursing home samples

Brief details of the analytical methods for each type of sample are listed below.

Water	Detection method:	Gas chromatography, nitrogen-phosphorous or flame photometric detector
	Sensitivity:	10ppt/8 pint sample (for malathion)
Fallout Sheets	Detection method:	Gas chromatography, nitrogen-phosphorous or flame photometric detector
	Sensitivity:	80 ng/sample (for malathion)
Tank Samples	Detection method:	Gas chromatography, flame ionization detector
	Std. deviation:	±0.2%
Hi-Vol and Low-Vol Samples		
	Resin:	XAD-2 (Rohm & Haas)
	Detection method:	Gas chromatography, nitrogen-phosphorous or flame photometric detector
	Sensitivity:	80 ng/sample (for malathion)

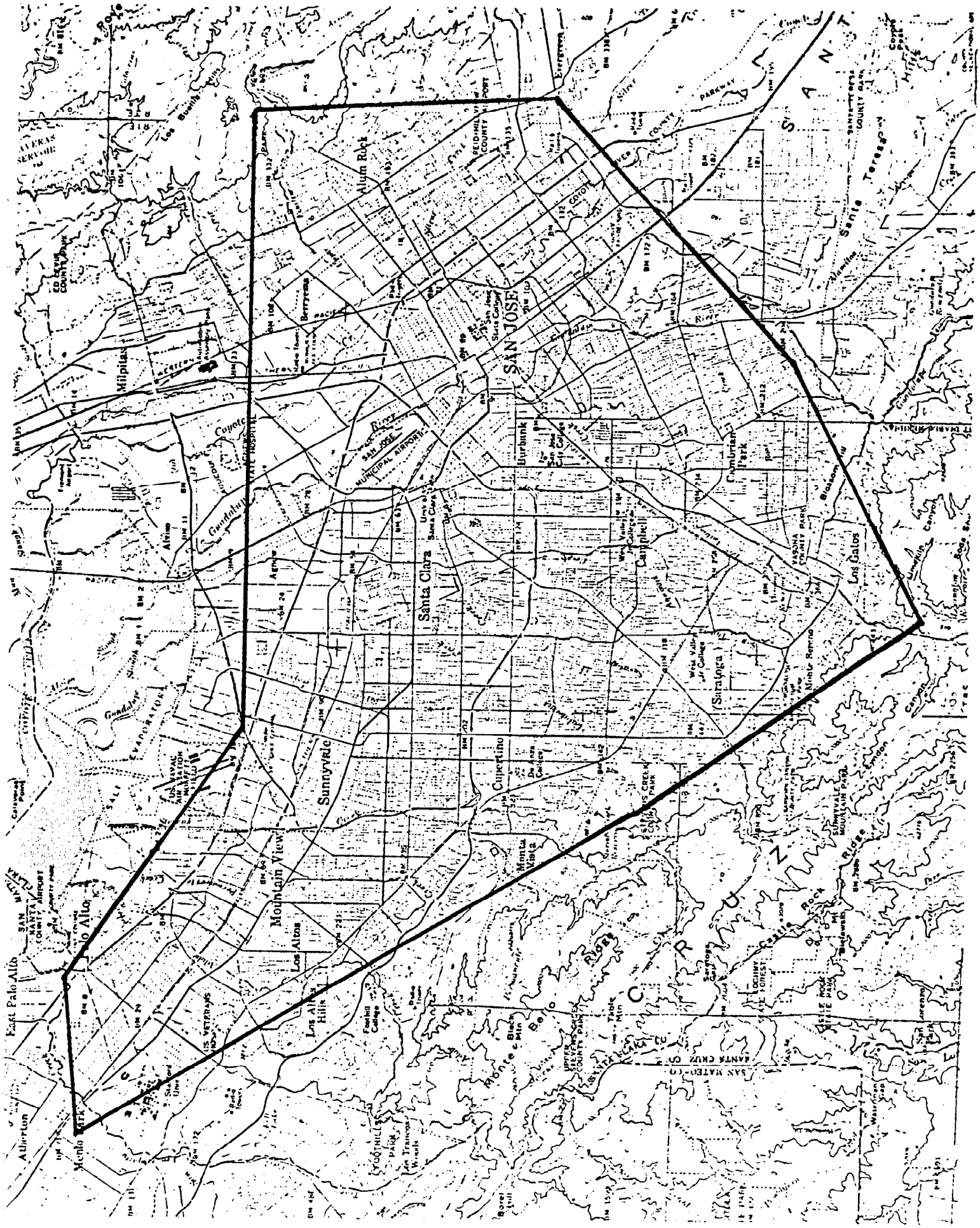

FIGURE 1. BOUNDARIES FOR CONTINGENCY MONITORING PLAN

A P P E N D I X II

Chain of Custody Form Used for Sample Security

STATE OF CALIFORNIA
DEPARTMENT OF FOOD
AND AGRICULTURE

CHAIN OF CUSTODY RECORD

USE BALL POINT PEN ONLY

ENVIRONMENTAL MONITORING & PEST MGMT.
ENVIRONMENTAL HAZARDS ASSESSMENT
1220 N STREET, ROOM A-328
SACRAMENTO, CALIFORNIA 95814

STUDY #	SAMPLE #	SAMPLER DATE ON MO.	DAY	YR.	TIME ON	SAMPLER DATE OFF MO.	DAY	YR.	TIME OFF	PERSON COLLECTING	SAMPLE TYPE: TANK SAMPLE	HIGH VOL	LV	BIOTA	FALLOUT UCD	FALLOUT CDFA	WATER	FLOATER	SOIL OR LEAVES	OTHER
1 5				8 1				8 1												

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40

SAMPLE LOCATION

41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

REMARKS, OBSERVATIONS, OTHER CHEMICALS USED, ETC.
TYPE OF BIOTA:

LAB RESULTS *SAVE LEAVES*

MALATHION

ISOMALATHION

MALOXON

CHEMIST'S NAME DATE

Relinquished by: *(Signature)*	Date/Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date/Time
Received by *(Signature)*	Relinquished by *(Signature)*	Date/Time	Received by: *(Signature)*	
Relinquished by: *(Signature)*	Date/Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date/Time
Received by *(Signature)*	Relinquished by *(Signature)*	Date/Time	Received by: *(Signature)*	
Relinquished by: *(Signature)*	Date/Time	Received for Laboratory by: *(Signature)*	Date/Time	

Distribution: Original and One Copy Accompanies Shipment: Copy to Coordinator Field Files

A P P E N D I X III

Tables Summarizing Air Concentrations of Malathion and Malaoxon Collected Inside and Outside of Residences for Each Spray Week and the Average of 6 Spray Weeks

List of Tables

Appendix III

		Page
Table 1.	Malathion and Malaoxon in Air Samples from Residences; Spray No. 1	97
Table 2.	Malathion and Malaoxon in Air Samples from Residences; Spray No. 2	98
Table 3.	Malathion and Malaoxon in Air Samples from Residences; Spray No. 3	99
Table 4.	Malathion and Malaoxon in Air Samples from Residences; Spray No. 4	100
Table 5.	Malathion and Malaoxon in Air Samples from Residences; Spray No. 5	101
Table 6.	Malathion and Malaoxon in Air Samples from Residences; Spray No. 6	102
Table 7.	Malathion and Malaoxon in Air Samples from Residences; Sprays 1-6	103

Table 1 Concentrations ($\mu g/m^3$) of malathion and malaoxon in air samples collected inside and outside of residence using low volume samplers; spray no. 1 beginning July 14, 1981.

		Sampling period			
		24 hour background	6 hour spray	24 hour post spray	Second 24 hour post spray
Malathion					
Inside	N	20	18	19	19
	$\bar{X}$	0.0057	0.0171	0.0371	0.0265
	SE	0.0027	0.0056	0.0068	0.0041
	R	0.000 to 0.048	0.000 to 0.085	0.004 to 0.115	0.007 to 0.060
Outside	N	23	18	19	19
	$\bar{X}$	0.0062	0.0447	0.1285	0.1262
	SE	0.0023	0.0102	0.0210	0.0302
	R	0.000 to 0.050	0.005 to 0.154	0.046 to 0.426	0.034 to 0.627
Maloxon					
Inside	N	20	18	19	19
	$\bar{X}$	0.0001	0.0001	0.0001	0.0001
	SE	0.0000	0.0001	0.0001	0.0000
	R	0.0000 to 0.0006	0.0000 to 0.0008	0.0000 to 0.0006	0.0000 to 0.0005
Outside	N	23	18	19	19
	$\bar{X}$	0.0001	0.0001	0.0003	0.0003
	SE	0.0000	0.0000	0.0001	0.0001
	R	0.0000 to 0.0002	0.0000 to 0.0003	0.0000 to 0.0018	0.0000 to 0.0009

N=number of samples; $\bar{X}$=mean value; SE=standard error of mean; R=range.

Table 2 Concentrations ($\mu g/m^3$) of malathion and malaoxon in air samples collected inside and outside of residences using low volume samplers; spray no. 2 beginning July 23, 1981.

		Sampling period			
		24 hour background	6 hour spray	24 hour post spray	Second 24 hour post spray
Malathion					
Inside	N	23	25	26	26
	$\overline{X}$	0.0131	0.0398	0.0455	0.0327
	SE	0.0034	0.0179	0.0080	0.0043
	R	0.000 to 0.075	0.000 to 0.340	0.005 to 0.160	0.004 to 0.092
Outside	N	23	24	26	26
	$\overline{X}$	0.0342	0.1395	0.1695	0.1097
	SE	0.0071	0.0256	0.0207	0.0185
	R	0.000 to 0.127	0.000 to 0.414	0.022 to 0.458	0.010 to 0.413
Inside	N	23	25	26	26
	$\overline{X}$	0.0000	0.0001	0.0001	0.0002
	SE	0.0000	0.0000	0.0000	0.0000
	R	0.0000 to 0.0006	0.0000 to 0.0008	0.0000 to 0.0005	0.0000 to 0.0008
Outside	N	23	24	26	26
	$\overline{X}$	0.0001	0.0000	0.0004	0.0003
	SE	0.0000	0.0000	0.0001	0.0001
	R	0.0000 to 0.0009	0.0000 to 0.0003	0.0000 to 0.0017	0.0000 to 0.0010

N=number of samples; $\overline{X}$=mean value; SE=standard error of mean; R=range.

Table 3 Concentrations ($\mu g/m^3$) of malathion and malaoxon in air samples collected inside and outside of residences using low volume samplers; spray no. 3 beginning August 3, 1981.

		Sampling period			
		24 hour background	6 hour spray	24 hour post spray	Second 24 hour post spray
Malathion					
Inside	N	24	25	24	23
	$\bar{X}$	0.0186	0.0604	0.0629	0.0421
	SE	0.0042	0.0189	0.0156	0.0098
	R	0.000 to 0.088	0.000 to 0.391	0.006 to 0.403	0.005 to 0.230
Outside	N	25	25	25	24
	$\bar{X}$	0.0676	0.1679	0.2038	0.1316
	SE	0.0212	0.0425	0.0231	0.0171
	R	0.007 to 0.529	0.012 to 0.851	0.035 to 0.578	0.019 to 0.392
Maloxon					
Inside	N	24	25	24	23
	$\bar{X}$	0.0001	0.0000	0.0003	0.0002
	SE	0.0000	0.0000	0.0001	0.0000
	R	0.0000 to 0.0008	0.0000 to 0.0000	0.0000 to 0.0016	0.0000 to 0.0006
Outside	N	25	25	25	24
	$\bar{X}$	0.0002	0.0000	0.0006	0.0010
	SE	0.0001	0.0000	0.0001	0.0001
	R	0.0000 to 0.0021	0.0000 to 0.0003	0.0000 to 0.0027	0.0002 to 0.0033

N=number of samples; $\bar{X}$=mean value; SE=standard error of mean; R=range.

Table 4 Concentrations ($\mu g/m^3$) of malathion and malaoxon in air samples collected inside and outside of residences using low volume samplers; spray no. 4 beginning August 10, 1981.

		Sampling period			
		24 hour background	6 hour spray	24 hour post spray	Second 24 hour post spray
Malathion					
Inside	N	26	26	26	No data
	$\overline{X}$	0.0165	0.0412	0.0435	
	SE	0.0027	0.0088	0.0070	
	R	0.000 to 0.046	0.000 to 0.173	0.000 to 0.180	
Outside	N	25	26	26	No data
	$\overline{X}$	0.0495	0.1280	0.1553	
	SE	0.0061	0.0170	0.0101	
	R	0.010 to 0.138	0.000 to 0.346	0.019 to 0.254	
Maloxon					
Inside	N	26	26	26	No data
	$\overline{X}$	0.0003	0.0002	0.0003	
	SE	0.0001	0.0001	0.0001	
	R	0.0000 to 0.0017	0.0000 to 0.0015	0.0000 to 0.0009	
Outside	N	25	26	26	No data
	$\overline{X}$	0.0005	0.0000	0.0009	
	SE	0.0000	0.0000	0.0001	
	R	0.0001 to 0.0008	0.0000 to 0.0000	0.0002 to 0.0024	

N=number of samples; $\overline{X}$=mean value; SE=standard error of mean; R=range.

Table 5 Concentrations ($\mu g/m^3$) of malathion and malaoxon in air samples Collected inside and outside of residences using low volume samplers; spray no. 5 beginning August 17, 1981.

		Sampling period			
		24 hour background	6 hour spray	24 hour post spray	Second 24 hour post spray
Malathion					
Inside	N	25	25	21	No data
	$\bar{X}$	0.0174	0.0498	0.0599	
	SE	0.0018	0.0096	0.0101	
	R	0.004 to 0.040	0.000 to 0.195	0.004 to 0.147	
Outside	N	25	25	21	No data
	$\bar{X}$	0.0558	0.1812	0.2074	
	SE	0.0068	0.0254	0.0179	
	R	0.012 to 0.166	0.048 to 0.655	0.073 to 0.361	
Maloxon					
Inside	N	25	25	21	No data
	$\bar{X}$	0.0001	0.0001	0.0001	
	SE	0.000	0.001	0.000	
	R	0.0000 to 0.0006	0.0000 to 0.0012	0.0000 to 0.0005	
Outside	N	25	25	21	No data
	$\bar{X}$	0.0003	0.0000	0.0003	
	SE	0.0000	0.0000	0.0001	
	R	0.0000 to 0.0006	0.0000 to 0.0003	0.0000 to 0.0009	

N=number of samples; $\bar{X}$=mean value; SE=standard error of mean; R=range.

Table 6 Concentrations ($\mu g/m^3$) of malathion and malaoxon in air samples collected inside and outside of residences using low volume samplers; spray no. 6 beginning August 24, 1981.

		Sampling period			
		24 hour background	6 hour spray	24 hour post spray	Second 24 hour post spray
Malathion					
Inside	N	22	22	24	22
	$\bar{X}$	0.0335	0.0539	0.0617	0.0892
	SE	0.0043	0.0137	0.0071	0.0254
	R	0.015 to 0.104	0.000 to 0.286	0.009 to 0.163	0.025 to 0.585
Outside	N	22	24	24	22
	$\bar{X}$	0.1285	0.3550	0.3264	0.2590
	SE	0.0115	0.0599	0.0255	0.0244
	R	0.065 to 0.273	0.039 to 1.332	0.063 to 0.598	0.026 to 0.507
Maloxon					
Inside	N	22	22	24	22
	$\bar{X}$	0.002	0.000	0.002	0.003
	SE	0.000	0.000	0.001	0.001
	R	0.0000 to 0.0005	0.0000 to 0.0003	0.0000 to 0.0013	0.0000 to 0.0014
Outside	N	22	24	24	22
	$\bar{X}$	0.0005	0.0000	0.0008	0.0011
	SE	0.0001	0.0000	0.0002	0.0003
	R	0.0000 to 0.0013	0.0000 to 0.0000	0.0000 to 0.0042	0.0002 to 0.0046

N=number of samples; $\bar{X}$=mean value; SE=standard error of mean; R=range.

Table 7 Concentrations ($\mu g/m^3$) of malathion and malaoxon in air samples collected inside and outside of residences using low volume samplers; cumulative data for sprays 1-6.

		Sampling period			
		24 hour background	6 hour spray	24 hour post spray	Second 24 hour post spray
Malathion					
Inside	N	140	141	140	90
	$\bar{X}$	0.0176	0.0448	0.0519	0.0476
	SE	0.0015	0.0057	0.0040	0.0072
	R	0.000 to 0.104	0.000 to 0.391	0.000 to 0.403	0.004 to 0.585
Outside	N	143	142	141	91
	$\bar{X}$	0.0565	0.1741	0.1998	0.1550
	SE	0.0054	0.0161	0.0097	0.0125
	R	0.000 to 0.529	0.000 to 1.332	0.019 to 0.598	0.010 to 0.627
Maloxon					
Inside	N	140	141	140	90
	$\bar{X}$	0.001	0.001	0.002	0.002
	SE	0.000	0.000	0.000	0.000
	R	0.0000 to 0.0017	0.0000 to 0.0015	0.0000 to 0.0016	0.0000 to 0.0014
Outside	N	143	142	141	91
	$\bar{X}$	0.0003	0.0000	0.0006	0.0007
	SE	0.0000	0.0000	0.0001	0.0001
	R	0.0000 to 0.0021	0.0000 to 0.0005	0.0000 to 0.0042	0.0000 to 0.0046

N=number of samples; $\bar{X}$=mean value; SE=standard error of mean; R=range.

A P P E N D I X IV

Tables Summarizing Air Concentrations of Malaoxon in Air Sample from Hospitals and Nursing Homes during Each Spray Week and the Average of 6 Spray Weeks

List of Tables

Appendix IV

		Page
Table 1.	Malaoxon in Air Samples from Hospitals and Nursing Homes; Spray No. 1	106
Table 2.	Malaoxon in Air Samples from Hospitals and Nursing Homes; Spray No. 2	107
Table 3.	Malaoxon in Air Samples from Hospitals and Nursing Homes; Spray No. 3	108
Table 4.	Malaoxon in Air Samples from Hospitals and Nursing Homes; Spray No. 4	109
Table 5.	Malaoxon in Air Samples from Hospitals and Nursing Homes; Spray No. 5	110
Table 6.	Malaoxon in Air Samples from Hospitals and Nursing Homes; Spray No. 6	111
Table 7.	Malaoxon in Air Samples from Hospitals and Nursing Homes; Sprays 1 - 6	112

Table 1 Concentrations ($\mu g/m^3$) of malaoxon in air samples collected with high volume samplers; spray no. 1 beginning July 14, 1981.

Location		Sampling period			
		24 hour background	6 hour spray	24 hour post spray	Second 24 hour post spray
Hospital					
Inside	N	7	7	7	7
	$\bar{X}$	0.0001	0.0001	0.0026	0.0019
	SE	0.0001	0.0001	0.0023	0.0012
	R	0.0000 to 0.0006	0.0000 to 0.0004	0.0000 to 0.0166	0.0000 to 0.0082
Outside	N	7	7	6	8
	$\bar{X}$	0.0009	0.0000	0.0219	0.0117
	SE	0.0004	0.0000	0.0046	0.0045
	R	0.0000 to 0.0028	0.0000 to 0.0000	0.0066 to 0.0388	0.0000 to 0.0384
Nursing home					
Inside	N	6	5	5	6
	$\bar{X}$	0.0003	0.0000	0.0006	0.0016
	SE	0.0002	0.0000	0.0002	0.0012
	R	0.0000 to 0.0012	0.0000 to 0.0000	0.0000 to 0.0012	0.0000 to 0.0074
Outside	N	6	5	4	4
	$\bar{X}$	0.0011	0.0000	0.0340	0.0127
	SE	0.0004	0.0000	0.0197	0.0101
	R	0.0004 to 0.0028	0.0000 to 0.0000	0.0000 to 0.0848	0.0000 to 0.0426

N-number of samples; $\bar{X}$=mean value; SE=standard error of mean; R=range.

Table 2 Concentrations ($\mu g/m^3$) of malaoxon in air samples collected with high volume samplers; spray no. 2 beginning July 23, 1981.

Location		Sampling period			
		24 hour background	6 hour spray	24 hour post spray	Second 24 hour post spray
Hospital					
Inside	N	7	8	8	9
	$\bar{X}$	0.0024	0.0002	0.0020	0.0023
	SE	0.0007	0.0001	0.0008	0.0010
	R	0.0000 to 0.0051	0.0000 to 0.0008	0.0000 to 0.0055	0.0000 to 0.0082
Outside	N	7	8	8	8
	$\bar{X}$	0.0117	0.0000	0.0292	0.0276
	SE	0.0023	0.0000	0.0075	0.0077
	R	0.0044 to 0.0189	0.0000 to 0.0000	0.0048 to 0.0701	0.0013 to 0.0640
Nursing home					
Inside	N	6	7	8	6
	$\bar{X}$	0.0020	0.0001	0.0027	0.0052
	SE	0.0009	0.0001	0.0016	0.0029
	R	0.0000 to 0.0059	0.0000 to 0.0008	0.0000 to 0.0131	0.0000 to 0.0163
Outside	N	6	7	7	7
	$\bar{X}$	0.0112	0.0001	0.0359	0.0377
	SE	0.0054	0.0001	0.0113	0.0073
	R	0.0006 to 0.0326	0.0000 to 0.0006	0.0082 to 0.0823	0.0139 to 0.0657

N=number of samples; $\bar{X}$=mean value; SE=standard error of mean; R=range.

Table 3 Concentrations ($\mu g/m^3$) of malaoxon in air samples collected with high volume samplers; spray no. 3 beginning August 3, 1981.

Location		Sampling period			
		24 hour background	6 hour spray	24 hour post spray	Second 24 hour post spray
Hospital					
Inside	N	8	8	8	7
	$\bar{X}$	0.0004	0.0010	0.0011	0.0027
	SE	0.0003	0.0005	0.0007	0.0012
	R	0.0000 to 0.0027	0.0000 to 0.0036	0.0000 to 0.0055	0.0000 to 0.0079
Outside	N	8	9	8	8
	$\bar{X}$	0.0074	0.0000	0.0349	0.0413
	SE	0.0018	0.0000	0.0069	0.0102
	R	0.0000 to 0.0161	0.0000 to 0.0000	0.0079 to 0.0650	0.0119 to 0.1049
Nursing home					
Inside	N	7	7	7	6
	$\bar{X}$	0.0011	0.0018	0.0033	0.0003
	SE	0.0005	0.0009	0.0020	0.0002
	R	0.0000 to 0.0027	0.0000 to 0.0067	0.0000 to 0.0150	0.0000 to 0.0014
Outside	N	7	6	7	7
	$\bar{X}$	0.0103	0.0000	0.0206	0.0271
	SE	0.0030	0.0000	0.0100	0.0093
	R	0.0028 to 0.0214	0.0000 to 0.0000	0.0000 to 0.0767	0.0034 to 0.0736

N=number of samples; $\bar{X}$=mean value; SE=standard error of mean; R=range.

Table 4 Concentrations (μg/m3) of malaoxon in air samples collected with high volume samplers; spray no. 4 beginning August 10, 1981.

Location		Sampling period			
		24 hour background	6 hour spray	24 hour post spray	Second 24 hour post spray
Hospital					
Inside	N	8	7	7	No data
	$\bar{X}$	0.0020	0.0008	0.0026	
	SE	0.0007	0.0004	0.0017	
	R	0.0000 to 0.0063	0.0000 to 0.0027	0.0000 to 0.0126	
Outside	N	8	7	7	No data
	$\bar{X}$	0.0178	0.0001	0.0336	
	SE	0.0028	0.0001	0.0048	
	R	0.0088 to 0.0276	0.0000 to 0.0006	0.0156 to 0.0487	
Nursing home					
Inside	N	7	7	7	No data
	$\bar{X}$	0.0019	0.0008	0.0066	
	SE	0.0011	0.0003	0.0033	
	R	0.0000 to 0.0067	0.0000 to 0.0019	0.0000 to 0.0233	
Outside	N	7	7	7	No data
	$\bar{X}$	0.0221	0.0006	0.0234	
	SE	0.0041	0.0006	0.0060	
	R	0.0044 to 0.0395	0.0000 to 0.0040	0.0014 to 0.0518	

N=number of samples; $\bar{X}$=mean value; SE=standard error of mean; R=range.

Table 5 Concentrations ($\mu g/m^3$) of malaoxon in air samples collected with high volume samplers; spray no. 5 beginning August 17, 1981.

Location		Sampling period			
		24 hour background	6 hour spray	24 hour post spray	Second 24 hour post spray
Hospital					
Inside	N	7	7	6	No data
	$\bar{X}$	0.0023	0.0016	0.0026	
	SE	0.0012	0.0004	0.0012	
	R	0.0000 to 0.0086	0.0001 to 0.0027	0.0000 to 0.0062	
Outside	N	7	7	6	No data
	$\bar{X}$	0.0116	0.0007	0.0231	
	SE	0.0028	0.0007	0.0069	
	R	0.0042 to 0.0222	0.0000 to 0.0047	0.0000 to 0.0411	
Nursing home					
Inside	N	7	7	6	No data
	$\bar{X}$	0.0018	0.0005	0.0029	
	SE	0.0010	0.0002	0.0016	
	R	0.0000 to 0.0073	0.0000 to 0.0012	0.0000 to 0.0100	
Outside	N	7	7	7	No data
	$\bar{X}$	0.0157	0.0006	0.0150	
	SE	0.0033	0.0004	0.0067	
	R	0.0040 to 0.0303	0.0000 to 0.0028	0.0000 to 0.0449	

N=number of samples; $\bar{X}$=mean value; SE=standard error of mean; R=range.

Table 6 Concentrations ($\mu g/m^3$) of malaoxon in air samples collected with high volume samplers; spray no. 6 beginning August 24, 1981.

Location		Sampling period			
		24 hour background	6 hour spray	24 hour post spray	Second 24 hour post spray
Hospital					
Inside	N	7	7	7	6
	$\bar{X}$	0.0007	0.0004	0.0337	0.0042
	SE	0.0004	0.0004	0.0330	0.0017
	R	0.0000 to 0.0026	0.0000 to 0.0028	0.0000 to 0.2319	0.0000 to 0.0098
Outside	N	7	7	7	7
	$\bar{X}$	0.0154	0.0000	0.0464	0.0485
	SE	0.0024	0.0000	0.0124	0.0068
	R	0.0094 to 0.0278	0.0000 to 0.0000	0.0002 to 0.1025	0.0283 to 0.0791
Nursing home					
Inside	N	6	6	6	6
	$\bar{X}$	0.0018	0.0003	0.0069	0.0065
	SE	0.0010	0.0003	0.0032	0.0035
	R	0.0000 to 0.0061	0.0000 to 0.0016	0.0000 to 0.0166	0.0000 to 0.0209
Outside	N	5	6	6	6
	$\bar{X}$	0.0236	0.0000	0.0518	0.0508
	SE	0.0096	0.0000	0.0197	0.0146
	R	0.0031 to 0.0516	0.0000 to 0.0000	0.0000 to 0.1430	0.0058 to 0.1020

N=number of samples; $\bar{X}$=mean value; SE=standard error of mean; R=range.

Table 7 Concentrations ($\mu g/m^3$) of malaoxon in air samples collected with high volume samplers; cumulative data for sprays 1-6.

Location		Sampling period			
		24 hour background	6 hour spray	24 hour post spray	Second 24 hour post spray
Hospital					
Inside	N	44	44	43	29
	$\bar{X}$	0.0013	0.0007	0.0073	0.0027
	SE	0.0003	0.0002	0.0054	0.0006
	R	0.0000 to 0.0086	0.0000 to 0.0036	0.0000 to 0.2319	0.0000 to 0.0098
Outside	N	44	45	42	31
	$\bar{X}$	0.0109	0.0001	0.0320	0.0317
	SE	0.0012	0.0001	0.0032	0.0044
	R	0.0000 to 0.0278	0.0000 to 0.0047	0.0000 to 0.1025	0.0000 to 0.1049
Nursing home					
Inside	N	39	39	39	24
	$\bar{X}$	0.0015	0.0006	0.0039	0.0034
	SE	0.0003	0.0002	0.0010	0.0012
	R	0.0000 to 0.0073	0.0000 to 0.0067	0.0000 to 0.0233	0.0000 to 0.0209
Outside	N	38	38	38	24
	$\bar{X}$	0.0139	0.0002	0.0292	0.0337
	SE	0.0021	0.0001	0.0050	0.0056
	R	0.0004 to 0.0516	0.0000 to 0.0040	0.0000 to 0.1430	0.0000 to 0.1020

N=number of samples; $\bar{X}$=mean value; SE=standard error of mean; R=range.

A P P E N D I X V

Tables Summarizing Air Concentrations of Malathion in Air Samples from Hospitals and Nursing Homes during Each Spray Week and the Average of 6 Spray Weeks

List of Tables

Appendix V

		Page
Table 1.	Malathion in Air Samples from Hospitals and Nursing Homes; Spray No. 1	115
Table 2.	Malathion in Air Samples from Hospitals and Nursing Homes; Spray No. 2	116
Table 3.	Malathion in Air Samples from Hospitals and Nursing Homes; Spray No. 3	117
Table 4.	Malathion in Air Samples from Hospitals and Nursing Homes; Spray No. 4	118
Table 5.	Malathion in Air Samples from Hospitals and Nursing Homes; Spray No. 5	119
Table 6.	Malathion in Air Samples from Hospitals and Nursing Homes; Spray No. 6	120
Table 7.	Malathion in Air Samples from Hospitals and Nursing Homes; Sprays No. 1 - 6	121

Table 1. Concentrations ($\mu g/m^3$) of malathion in air samples collected with high volume samplers; spray no. 1 beginning July 14, 1981.

Location		Sampling period: 24 hour background	6 hour spray	24 hour post spray	Second 24 hour post spray
Hospital					
Inside	N	7	7	7	7
	$\overline{X}$	0.0014	0.0043	0.0108	0.0060
	SE	0.0012	0.0026	0.0047	0.0012
	R	0.000 to 0.009	0.000 to 0.019	0.002 to 0.038	0.002 to 0.012
Outside	N	7	7	6	6
	$\overline{X}$	0.0055	0.0901	0.0591	0.0248
	SE	0.0051	0.0156	0.0085	0.0098
	R	0.000 to 0.036	0.021 to 0.132	0.029 to 0.085	0.000 to 0.087
Nursing home					
Inside	N	6	5	5	6
	$\overline{X}$	0.0024	0.0202	0.0205	0.0144
	SE	0.0016	0.0178	0.0069	0.0062
	R	0.000 to 0.010	0.000 to 0.091	0.003 to 0.038	0.000 to 0.037
Outside	N	6	5	4	4
	$\overline{X}$	0.0014	0.5029	0.1561	0.1523
	SE	0.0003	0.3817	0.0581	0.0761
	R	0.000 to 0.002	0.008 to 2.023	0.031 to 0.292	0.037 to 0.367

N=number of samples; $\overline{X}$=mean value; SE=standard error of mean; R=range.

Table 2. Concentrations ($\mu g/m^3$) of malathion in air samples collected with high volume samplers; spray no. 2 beginning July 23, 1981.

Location		Sampling period			
		24 hour background	6 hour spray	24 hour post spray	Second 24 hour post spray
Hospital					
Inside	N	7	8	8	9
	$\overline{X}$	0.0044	0.0075	0.0117	0.0190
	SE	0.0015	0.0015	0.0039	0.0069
	R	0.002 to 0.013	0.002 to 0.014	0.004 to 0.037	0.000 to 0.058
Outside	N	7	8	8	8
	$\overline{X}$	0.0163	0.2489	0.0776	0.0532
	SE	0.0059	0.0704	0.0174	0.0078
	R	0.005 to 0.042	0.067 to 0.612	0.026 to 0.186	0.029 to 0.096
Nursing home					
Inside	N	6	7	8	6
	$\overline{X}$	0.0075	0.0078	0.0479	0.0180
	SE	0.0027	0.0018	0.0167	0.0044
	R	0.001 to 0.015	0.002 to 0.016	0.000 to 0.150	0.011 to 0.039
Outside	N	6	7	7	7
	$\overline{X}$	0.0390	0.4535	0.2254	0.1748
	SE	0.0156	0.2281	0.0622	0.0554
	R	0.002 to 0.100	0.010 to 1.634	0.015 to 0.437	0.032 to 0.433

N=number of samples; $\overline{X}$=mean value; SE=standard error of mean; R=range.

Table 3. Concentrations ($\mu g/m^3$) of malathion in air samples collected with high volume samplers; spray no. 3 beginning August 3, 1981.

Location		Sampling period			
		24 hour background	6 hour spray	24 hour post spray	Second 24 hour post spray
Hospital					
Inside	N	8	8	8	7
	$\bar{X}$	0.0249	0.0415	0.0163	0.0150
	SE	0.0199	0.0304	0.0048	0.0046
	R	0.000 to 0.164	0.002 to 0.252	0.002 to 0.035	0.000 to 0.031
Outside	N	8	9	8	8
	$\bar{X}$	0.0224	0.2667	0.1048	0.0768
	SE	0.0062	0.0894	0.0138	0.0113
	R	0.009 to 0.060	0.009 to 0.720	0.062 to 0.188	0.047 to 0.147
Nursing home					
Inside	N	7	7	7	6
	$\bar{X}$	0.0076	0.0100	0.0187	0.0206
	SE	0.0017	0.0046	0.0083	0.0052
	R	0.000 to 0.011	0.000 to 0.036	0.000 to 0.066	0.000 to 0.038
Outside	N	7	6	7	7
	$\bar{X}$	0.0490	0.2747	0.1647	0.0962
	SE	0.0090	0.0975	0.0281	0.0156
	R	0.007 to 0.083	0.021 to 0.669	0.021 to 0.262	0.024 to 0.133

N=number of samples; $\bar{X}$=mean value; SE=standard error of mean; R=range.

Table 4. Concentrations ($\mu g/m^3$) of malathion in air samples collected with high volume samplers; spray no. 4 beginning August 10, 1981.

Location		Sampling Period			
		24 hour background	6 hour spray	24 hour post spray	Second 24 hour post spray
Hospital					
Inside	N	8	7	7	No data
	$\bar{X}$	0.0085	0.0107	0.0148	
	SE	0.0022	0.0031	0.0051	
	R	0.001 to 0.018	0.002 to 0.023	0.002 to 0.038	
Outside	N	8	7	7	No data
	$\bar{X}$	0.0246	0.1450	0.0763	
	SE	0.0026	0.0309	0.0062	
	R	0.016 to 0.040	0.031 to 0.246	0.046 to 0.099	
Nursing home					
Inside	N	7	7	7	No data
	$\bar{X}$	0.0111	0.0509	0.0353	
	SE	0.0027	0.0270	0.0048	
	R	0.000 to 0.021	0.003 to 0.190	0.018 to 0.059	
Outside	N	7	7	7	No data
	$\bar{X}$	0.0437	0.1901	0.1878	
	SE	0.0077	0.0486	0.0526	
	R	0.006 to 0.067	0.024 to 0.365	0.024 to 0.407	

N=number of samples; $\bar{X}$=mean value; SE=standard error of mean; R-range.

Table 5. Concentrations ($\mu g/m^3$) of malathion in air samples collected with high volume samplers; spray no. 5 beginning August 17, 1981

Location		Sampling Period: 24 hour background	6 hour spray	24 hour post spray	Second 24 hour post spray
Hospital					
Inside	N	7	7	6	No data
	$\bar{X}$	0.0063	0.0144	0.0744	
	SE	0.0021	0.0036	0.0562	
	R	0.001 to 0.015	0.003 to 0.030	0.004 to 0.353	
Outside	N	7	7	6	No data
	$\bar{X}$	0.0195	0.1872	0.1423	
	SE	0.0048	0.0640	0.0434	
	R	0.008 to 0.041	0.055 to 0.524	0.035 to 0.303	
Nursing home					
Inside	N	7	7	6	No data
	$\bar{X}$	0.0106	0.0177	0.0224	
	SE	0.0024	0.0081	0.0047	
	R	0.003 to 0.020	0.006 to 0.066	0.006 to 0.039	
Outside	N	7	7	7	No data
	$\bar{X}$	0.0348	0.2806	0.1500	
	SE	0.0065	0.1201	0.0322	
	R	0.008 to 0.062	0.029 to 0.907	0.031 to 0.284	

N=number of samples; $\bar{X}$=mean value; SE=standard error of mean; R=range

Table 6. Concentrations ($\mu g/m^3$) of malathion in air samples collected with high volume samplers; spray no. 6 beginning August 24, 1981.

Location		Sampling Period			
		24 hour background	6 hour spray	24 hour post spray	Second 24 hour post spray
Hospital					
Inside	N	7	7	7	6
	$\overline{X}$	0.0117	0.0177	0.2690	0.0210
	SE	0.0035	0.0049	0.1767	0.0062
	R	0.003 to 0.024	0.002 to 0.037	0.003 to 1.213	0.008 to 0.048
Outside	N	7	7	7	7
	$\overline{X}$	0.0492	0.2337	0.1157	0.1104
	SE	0.0111	0.0337	0.0252	0.0158
	R	0.019 to 0.096	0.129 to 0.396	0.005 to 0.198	0.033 to 0.155
Nursing Home					
Inside	N	6	6	6	6
	$\overline{X}$	0.0077	0.0160	0.0339	0.0277
	SE	0.0028	0.0063	0.0072	0.0072
	R	0.000 to 0.019	0.004 to 0.044	0.010 to 0.064	0.006 to 0.056
Outside	N	5	6	6	6
	$\overline{X}$	0.0589	0.2752	0.1704	0.1721
	SE	0.0130	0.0869	0.0325	0.0302
	R	0.021 to 0.097	0.027 to 0.512	0.040 to 0.262	0.051 to 0.264

N=number of samples; $\overline{X}$=mean value; SE=standard error of mean; R=range.

Table 7. Concentrations ($\mu g/m^3$) of malathion in air samples collected with high volume samplers; cumulative data for sprays 1-6

Location		Sampling Period: 24 hour background	6 hour spray	24 hour post spray	Second 24 hour post spray
Hospital					
Inside	N	44	44	43	29
	$\overline{X}$	0.0099	0.0164	0.0635	0.0153
	SE	0.0037	0.0057	0.0314	0.0028
	R	0.000 to 0.164	0.000 to 0.252	0.002 to 1.213	0.000 to 0.058
Outside	N	44	45	42	31
	$\overline{X}$	0.0229	0.1996	0.0955	0.0649
	SE	0.0031	0.0256	0.0092	0.0078
	R	0.000 to 0.096	0.009 to 0.720	0.005 to 0.303	0.000 to 0.155
Nursing Home					
Inside	N	39	39	39	24
	$\overline{X}$	0.0080	0.0205	0.0308	0.0202
	SE	0.0010	0.0058	0.0043	0.0029
	R	0.000 to 0.021	0.000 to 0.190	0.000 to 0.150	0.000 to 0.056
Outside	N	38	38	38	24
	$\overline{X}$	0.0376	0.3232	0.1774	0.1475
	SE	0.0046	0.0693	0.0179	0.0218
	R	0.000 to 0.100	0.008 to 2.023	0.015 to 0.437	0.024 to 0.433

N=number of samples; $\overline{X}$=mean value; SE=standard error of mean; R=range.

A P P E N D I X VI

Tables Summarizing Concentrations of Malathion and Malaoxon in Water Samples from Each Spray Week and the Average of 6 Spray Weeks

List of Tables

Appendix VI

		Page
Table 1.	Malathion and Malaoxon Samples from Reservoirs and Natural Waters; Spray No. 1	124
Table 2.	Malathion and Malaoxon Samples from Swimming Pools and other Man-Made Water Bodies; Spray No. 1	125
Table 3.	Malathion and Malaoxon Samples from Reservoirs and Natural Waters; Spray No. 2	126
Table 4.	Malathion and Malaoxon Samples from Swimming Pools and other Man-Made Water Bodies; Spray No. 2	127
Table 5.	Malathion and Malaoxon Samples from Reservoirs and Natural Waters; Spray No. 3	128
Table 6.	Malathion and Malaoxon Samples from Swimming Pools and other Man-Made Water Bodies; Spray No. 3	129
Table 7.	Malathion and Malaoxon Samples from Reservoirs and Natural Waters; Spray No. 4	130
Table 8.	Malathion and Malaoxon Samples from Swimming Pools and other Man-Made Water Bodies; Spray No. 4	131
Table 9.	Malathion and Malaoxon Samples from Reservoirs and Natural Waters; Spray No. 5	132
Table 10.	Malathion and Malaoxon Samples from Swimming Pools and other Man-Made Water Bodies; Spray No. 5	133
Table 11.	Malathion and Malaoxon Samples from Reservoirs and Natural Waters; Spray No. 6	134
Table 12.	Malathion and Malaoxon Samples from Swimming Pools and other Man-Made Water Bodies; Spray No. 6	135
Table 13.	Malathion and Malaoxon Samples from Reservoirs and Natural Waters; Sprays 1-6	136
Table 14.	Malathion and Malaoxon Samples from Swimming Pools and other Man-Made Water Bodies; Sprays 1-6	137

Table 1 . Concentrations of malathion and malaoxon in water samples collected from reservoirs and natural waters; spray no. 1 beginning July 14, 1981.

		Malathion (ppb)		Malaoxon (ppb)	
		Background	Spray	Background	Spray
Reservoirs		No data	No data	No data	No data
Natural waters					
Non-flagged	N	No data	14	No data	No data
	$\overline{X}$	"	4.9416	"	"
	SE	"	2.7181	"	"
	R	"	0.00 to 39.00	"	"
Flagged and Outside	N	20	20	No data	No data
	$\overline{X}$	0.0905	0.3320	"	"
	SE	0.0578	0.0775	"	"
	R	0.00 to 0.96	0.00 to 1.30	"	"

N=number of samples; $\overline{X}$=mean value; SE=standard error of mean; R=range.

Table 2 . Concentrations of malathion and malaoxon in water samples collected from swimming pools and other man-made water bodies; spray no. 1 beginning July 14, 1981.

		Malathion (ppb)		Malaoxon (ppb)	
		Background	Spray	Background	Spray
Swimming pools					
Non-flagged	N[1/]	No data	8	No data	4[2/]
	$\bar{X}$	"	0.3000	"	5.1500
	SE	"	0.3000	"	2.0234
	R	"	0.00 to 2.40	"	1.70 to 11.00
Other man-made water bodies					
Non-flagged	N	No data	4	No data	No data
	$\bar{X}$	"	42.7700	"	"
	SE	"	42.4106	"	"
	R	"	0.00 to 170.00	"	"
Flagged and outside	N	No data	6	No data	No data
	$\bar{X}$	"	1.1033	"	"
	SE	"	0.6714	"	"
	R	"	0.00 to 4.20	"	"

[1/] N=number of samples; $\bar{X}$=mean value; SE=standard error mean; R=range.

[2/] Only data with positive values were included in statistical calculations.

Table 3 . Concentrations of malathion and malaoxon in water samples collected from reservoirs and natural waters; spray no. 2 beginning July 23, 1981.

		Malathion (ppb)		Malaoxon (ppb)	
		Background	Spray	Background	Spray
Reservoirs					
Flagged	N	2	2	No data	1
	$\overline{X}$	0.1750	0.7500	"	2.7000
	SE	0.0250	0.6500	"	0.0000
	R	0.15 to 0.20	0.10 to 1.40	"	2.70 to 2.70
Outside	N	2	2	No data	No data
	$\overline{X}$	0.0500	0.3350	"	"
	SE	0.0500	0.0650	"	"
	R	0.00 to 0.10	0.27 to 0.40	"	"
Natural waters					
Non-flagged	N	6	16	No data	1
	$\overline{X}$	0.1983	18.6644	"	18.0000
	SE	0.0518	5.8129	"	0.0000
	R	0.00 to 0.40	0.00 to 90.00	"	18.00 to 18.00
Flagged and Outside	N	20	20	No data	No data
	$\overline{X}$	0.1200	0.5625	"	"
	SE	0.0742	0.1027	"	"
	R	0.00 to 1.5	0.00 to 1.50	"	"

N=number of samples; $\overline{X}$=mean value; SE=standard error ofmean; R=range.

Table 4 . Concentrations of malathion and malaoxon in water samples collected from swimming pools and other man-made water bodies; spray no. 2 beginning July 23, 1981.

		Malathion (ppb)		Malaoxon (ppb)	
		Background	Spray	Background	Spray
Swimming pools					
Non-flagged	N[1/]	4	12	No data	5[2/]
	$\bar{X}$	0.1800	0.1083	"	8.6200
	SE	0.0898	0.0468	"	2.4671
	R	0.00 to 0.42	0.00 to 0.40	"	1.00 to 15.00
Other man-made water bodies					
Non-flagged	N	2	8	No data	2
	$\bar{X}$	0.0500	3.1525	"	4.6250
	SE	0.0500	1.9793	"	3.3750
	R	0.00 to 0.10	0.00 to 16.00	"	1.25 to 8.00
Flagged and outside	N	14	12	No data	No data
	$\bar{X}$	0.1093	0.9642	"	"
	SE	0.0425	0.5529	"	"
	R	0.00 to 0.50	0.00 to 6.10	"	"

[1/] N-number of samples; $\bar{X}$=mean value; SE=standard error mean; R=range.

[2/] Only data with positive values were included in statistical calculations.

Table 5 . Concentrations of malathion and malaoxon in water samples collected from reservoirs and natural waters; spray no. 3 beginning August 3, 1981.

		Malathion (ppb)		Malaoxon (ppb)	
		Background	Spray	Background	Spray
Reservoirs					
Flagged	N	No data	2	No data	No data
	$\bar{X}$	"	0.5000	"	"
	SE	"	0.1000	"	"
	R	"	0.40 to 0.60	"	"
Outside	N	2	4	No data	No data
	$\bar{X}$	0.1000	1.000	"	"
	SE	0.1000	0.5523	"	"
	R	0.00 to 0.20	0.00 to 2.10	"	"
Natural waters					
Non-flagged	N	15	13	No data	No data
	$\bar{X}$	1.5040	9.7769	"	"
	SE	1.1799	2.4707	"	"
	R	0.00 to 18.00	0.36 to 27.00	"	"
Flagged and Outside	N	19	20	No data	No data
	$\bar{X}$	0.0563	0.8980	"	"
	SE	0.0284	0.1546	"	"
	R	0.00 to 0.50	0.30 to 2.5	"	"

N=number of samples; $\bar{X}$=mean value; SE=standard error of mean; R=range.

Table 6 . Concentrations of malathion and malaoxon in water samples collected from swimming pools and other man-made water bodies; spray no. 3 beginning August 3, 1981.

		Malathion (ppb)		Malaoxon (ppb)	
		Background	Spray	Background	Spray
Swimming pools					
Non-flagged	N	10	12	1	6
	$\overline{X}$	0.0500	2.6808	7.0000	3.2333
	SE	0.0279	1.9151	0.0000	0.3084
	R	0.00 to 0.25	0.00 to 23.00	7.00 to 7.00	2.30 to 4.30
Other man-made water bodies					
Non-flagged	N	6	5	No data	1
	$\overline{X}$	0.0333	6.6500	"	5.1000
	SE	0.0211	4.1710	"	0.0000
	R	0.00 to 0.10	0.00 to 20.00	"	5.10 to 5.10
Flagged and outside	N	9	12	No data	No data
	$\overline{X}$	0.0500	0.4842	"	"
	SE	0.3330	0.2565	"	"
	R	0.00 to 0.25	0.00 to 3.10	"	"

N-number of samples; $\overline{X}$=mean value; SE=standard error mean; R=range.

Only data with positive values were included in statistical calcualtion.

Table 7 . Concentrations of malathion and malaoxon in water samples collected from reservoirs and natural waters; spray no. 4 beginning August 10, 1981.

		Malathion (ppb)		Malaoxon (ppb)	
		Background	Spray	Background	Spray
Reservoirs					
Flagged	N	9	10	No data	2
	$\overline{X}$	0.0333	8.3900	"	0.9150
	SE	0.0236	3.8118	"	0.2850
	R	0.00 to 0.20	0.60 to 32.00	"	0.63 to 1.20
Outside	N	10	10	No data	No data
	$\overline{X}$	0.0300	0.2950	"	"
	SE	0.0300	0.1554	"	"
	R	0.00 to 0.30	0.00 to 1.60	"	"
Natural waters					
Non-flagged	N	15	14	1	2
	$\overline{X}$	0.4787	95.3857	0.6400	1.9000
	SE	0.1275	53.1720	0.0000	0.2000
	R	0.00 to 1.90	2.50 to 703.00	0.64 to 0.64	1.70 to 2.10
Flagged and Outside	N	14	15	No data	No data
	$\overline{X}$	0.1179	1.2533	"	"
	SE	0.0658	0.2192	"	"
	R	0.00 to 0.90	0.30 to 3.40	"	"

N=number of samples; $\overline{X}$=mean value; SE=standard error of mean; R=range.

Table 8 . Concentrations of malathion and malaoxon in water samples collected from swimming pools and other man-made bodies; spray no. 4 beginning August 10, 1981.

		Malathion (ppb)		Malaoxon (ppb)	
		Background	Spray	Background	Spray
Swimming pools					
Non-flagged	N	10	13	1	12
	$\overline{X}$	0.0000	0.0000	2.2000	8.4500
	SE	0.0000	0.0000	0.0000	2.3017
	R	0.00 to 0.00	0.00 to 0.00	2.20 to 2.20	0.90 to 29.50
Other man-made water bodies					
Non-flagged	N	8	8	2	2
	$\overline{X}$	0.0375	4.8750	0.7200	5.5000
	SE	0.0263	2.1895	0.5800	3.0000
	R	0.00 to 0.20	0.00 to 17.00	0.14 to 1.30	2.50 to 8.50
Flagged and outside	N	12	12	No data	1
	$\overline{X}$	0.0167	0.2617	"	0.5000
	SE	0.0167	0.1085	"	0.0000
	R	0.00 to 0.20	0.00 to 1.10	"	0.50 to 0.50

N=number of samples; $\overline{X}$=mean value; SE=standard error of mean; R=range.

Only data with positive values were included in statistical calculations.

Table 9 . Concentrations of malathion and malaoxon in water samples collected from reservoirs and natural waters; spray no. 5 beginning August 17, 1981.

		Malathion (ppb)		Malaoxon (ppb)	
		Background	Spray	Background	Spray
Reservoirs					
Flagged	N	10	12	No data	No data
	$\bar{X}$	0.5100	1.9000	"	"
	SE	0.2994	0.9405	"	"
	R	0.00 to 2.30	0.00 to 11.20	"	"
Outside	N	10	10	1	No data
	$\bar{X}$	0.0360	0.1440	1.3000	"
	SE	0.0242	0.0580	0.0000	"
	R	0.00 to 0.20	0.00 to 0.60	1.30 to 1.30	"
Natural waters					
Non-flagged	N	14	13	5	4
	$\bar{X}$	0.6593	4.9692	0.1900	0.6300
	SE	0.1156	1.0478	0.0458	0.1700
	R	0.00 to 1.30	0.50 to 11.90	0.10 to 0.30	0.30 to 1.10
Flagged and Outside	N	20	22	1	No data
	$\bar{X}$	0.0400	2.1045	0.4000	"
	SE	0.0197	0.4176	0.0000	"
	R	0.00 to 0.30	0.30 to 7.70	0.40 to 0.40	"

N=number of samples; $\bar{X}$=mean value; SE=standard error of mean; R=range.

Only data with positive values were included in statistical calculations.

Table 10 . Concentrations of malathion and malaoxon in water samples collected from swimming pools and other man-made water bodies; spray no. 5 beginning August 17, 1981.

		Malathion (ppb)		Malaoxon (ppb)	
		Background	Spray	Background	Spray
Swimming pools					
Non-flagged	N	12	12	5	12
	$\bar{X}$	0.1550	0.2667	1.5720	13.8167
	SE	0.0880	0.1864	1.1087	2.9446
	R	0.00 to 0.95	0.00 to 2.00	0.30 to 6.00	1.60 to 35.00
Other man-made water bodies					
Non-flagged	N	8	8	2	2
	$\bar{X}$	0.2250	6.4875	0.4000	17.2000
	SE	0.1750	2.1991	0.0000	7.8000
	R	0.00 to 1.40	0.00 to 16.00	0.40 to 0.40	9.40 to 25.0
Flagged and outside	N	8	8	No data	1
	$\bar{X}$	0.0537	0.7675	"	0.6000
	SE	0.0262	0.2812	"	0.0000
	R	0.00 to 0.15	0.00 to 2.10	"	0.60 to 0.60

N=number of samples; $\bar{X}$=mean value; SE=standard error mean; R=range.

Only data with positive values were included in statistical calculations.

Table 11 . Concentrations of malathion and malaoxon in water samples collected from reservoirs and natural waters; spray no. 6 beginning August 24, 1981.

		Malathion (ppb)		Malaoxon (ppb)	
		Background	Spray	Background	Spray
Reservoirs					
Flagged	N	8	8	1	1
	$\bar{X}$	0.0750	1.4162	0.1000	0.8300
	SE	0.0620	0.4081	0.0000	0.0000
	R	0.00 to 0.50	0.00 to 3.30	0.10 to 0.10	0.83 to 0.83
Outside	N	10	8	No data	No data
	$\bar{X}$	0.1750	0.2125	"	"
	SE	0.0735	0.0871	"	"
	R	0.00 to 0.70	0.00 to 0.70	"	"
Natural waters					
Non-flagged	N	12	11	1	4
	$\bar{X}$	0.5700	23.3909	0.9000	0.3500
	SE	0.2007	11.5836	0.0000	0.1041
	R	0.00 to 1.90	0.00 to 131.00	0.90 to 0.90	0.10 to 0.60
Flagged and outside	N	15	19	No data	2
	$\bar{X}$	0.0533	0.3947	"	0.4500
	SE	0.0401	0.0890	"	0.2500
	R	0.00 to 0.60	0.00 to 1.40	"	0.20 to 0.70

N=number of samples; $\bar{X}$=mean value; SE=standard error of mean; R=range.

Only data with positive values were included in statistical calculations.

Table 12 . Concentrations of malathion and malaoxon in water samples collected from swimming pools and other man-made water bodies; spray no. 6 beginning August 24, 1981.

		Malathion (ppb)		Malaoxon (ppb)	
		Background	Spray	Background	Spray
Swimming pools					
Non-flagged	N	10	12	3	10
	$\bar{X}$	0.0750	1.9083	0.2333	4.6500
	SE	0.0403	1.3504	0.0333	1.0341
	R	0.00 to 0.30	0.00 to 14.90	0.20 to 0.30	1.60 to 10.00
Other man-made water bodies					
Non-flagged	N	9	8	1	2
	$\bar{X}$	0.2667	13.6750	0.8000	12.5000
	SE	0.0986	4.0434	0.0000	0.5000
	R	0.00 to 0.70	0.00 to 34.70	0.80 to 0.80	12.00 to 13.00
Flagged and outside	N	10	10	No data	5
	$\bar{X}$	0.4000	0.7000	"	1.1200
	SE	0.3565	0.2936	"	0.9452
	R	0.00 to 3.60	0.00 to 2.40	"	0.10 to 4.90

N=number of samples; $\bar{X}$=mean value; SE=standard error mean; R=range.

Only data with positive values were included in statistical calculations.

Table 13 . Concentrations of malathion and malaoxon in water samples collected from reservoirs and natural waters; cumulative data for sprays 1-6.

		Malathion (ppb)		Malaoxon (ppb)	
		Background	Spray	Background	Spray
Reservoirs					
Flagged	N	29	34	1	4
	$\bar{X}$	0.2190	3.5450	0.1000	1.3400
	SE	0.1090	1.2568	0.0000	0.4685
	R	0.00 to 2.30	0.00 to 32.00	0.10 to 0.10	0.63 to 2.70
Outside	N	34	34	1	No data
	$\bar{X}$	0.0797	0.3165	1.3000	"
	SE	0.0264	0.0887	0.0000	"
	R	0.00 to 0.70	0.00 to 2.10	1.30 to 1.30	"
Natural waters					
Non-flagged	N	62	81	7	11
	$\bar{X}$	0.7581	26.5705	0.3557	2.3382
	SE	0.2891	9.8098	0.1151	1.5774
	R	0.00 to 18.00	0.00 to 703.00	0.10 to 0.90	0.10 to 18.00
Flagged and outside	N	108	116	1	2
	$\bar{X}$	0.0790	0.9349	0.4000	0.4500
	SE	0.0208	0.1081	0.0000	0.2500
	R	0.00 to 1.50	0.00 to 7.70	0.40 to 0.40	0.20 to 0.70

N=number of samples; $\bar{X}$=mean value; SE=standard error of mean; R=range.

Only data with positive values were included in statistical calculations.

Table 14 . Concentrations of malathion and malaoxon in water samples collected from swimming pools and other man-made water bodies; cumulative data for sprays 1-6.

		Malathion (ppb)		Malaoxon (ppb)	
		Background	Spray	Background	Spray
Swimming pools					
Non-flagged	N	46	69	10	49
	$\bar{X}$	0.0833	0.8981	1.7760	8.0979
	SE	0.0271	0.4157	0.8125	1.0920
	R	0.00 to 0.95	0.00 to 23.00	0.20 to 7.00	0.90 to 35.00
Other man-made water bodies					
Non-flagged	N	33	41	5	9
	$\bar{X}$	0.1455	10.4841	0.6080	9.4167
	SE	0.0519	4.1862	0.2026	2.3522
	R	0.00 to 1.40	0.00 to 170.00	0.14 to 1.30	1.25 to 25.00
Flagged and outside	N	53	60	No data	7
	$\bar{X}$	0.1247	0.6713	"	0.9571
	SE	0.0682	0.1512	"	0.6608
	R	0.00 to 3.60	0.00 to 6.10	"	0.10 to 4.90

N=number of samples; $\bar{X}$=mean value; SE=standard error mean; R=range.

Only data with positive values were included in statistical calculations.